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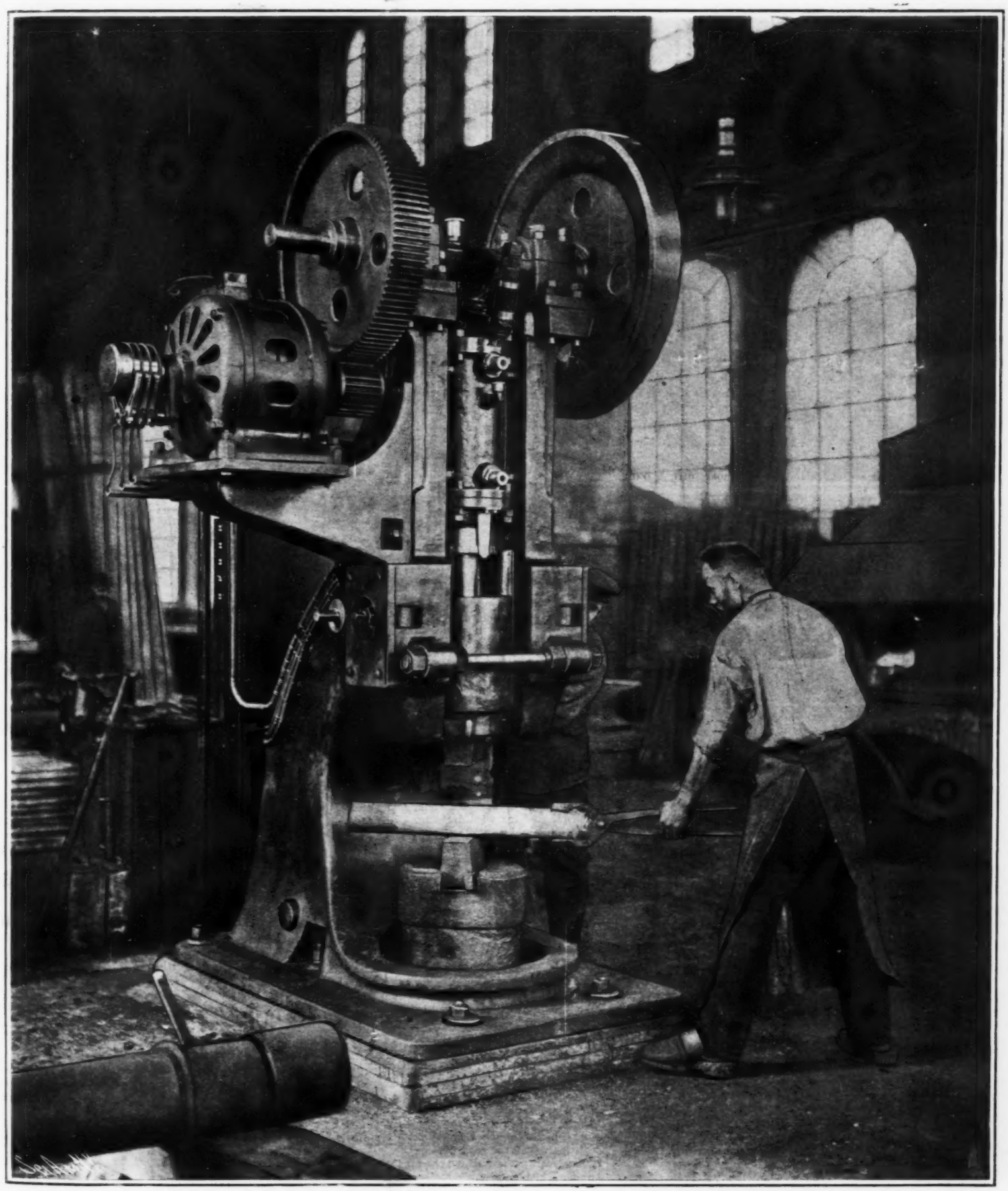


A GERMAN PNEUMATIC POWER HAMMER DRIVEN BY A THREE-PHASE ALTERNATING-CURRENT MOTOR.

ELECTRICALLY-OPERATED PNEUMATIC HAMMERS.*

By FRANK C. PERKINS.

ELECTRIC power has been utilized to a considerable extent for operating pneumatic power hammers in England and Germany, as well as in the United States, and they have given good service, possessing many features of merit.

The accompanying illustration shows an English one-ton electro-pneumatic power hammer, which it is claimed does the work of a steam hammer of the same size to better advantage, a greater amount of work being accomplished at one heat than with any other power work hammer having equal falling weight. This machine consists of a heavy standard to which the compressor and air cylinders are attached, the motor being mounted on the base plate and having a capacity of 50 brake horse-power. It will be noted that the compressor crank shaft is placed lengthwise of the base plate, and driven by electric power through spur gearing. This English electro-pneumatic power hammer is capable of delivering 85 blows per minute, the weight of the hammer being 20 hundredweight. It is stated that the longest stroke which can be obtained is 33 inches, and the clearance space between the slides is 1 foot 4 inches, while the die faces are each 10 inches by 14½ inches. The weight of this electrically-driven pneumatic hammer is 21 tons, and it occupies a floor space 5½ feet wide by 12½ feet long. The anvil face is 2 feet high from the base plate, and the slides 1 foot from the anvil die space. It is maintained that a bar having a diameter of 10 inches can be worked to advantage, and electric power is utilized with great economy. The anvil block as noted in the illustration rests independently on the foundation diagonally, and consists of a separate cast.

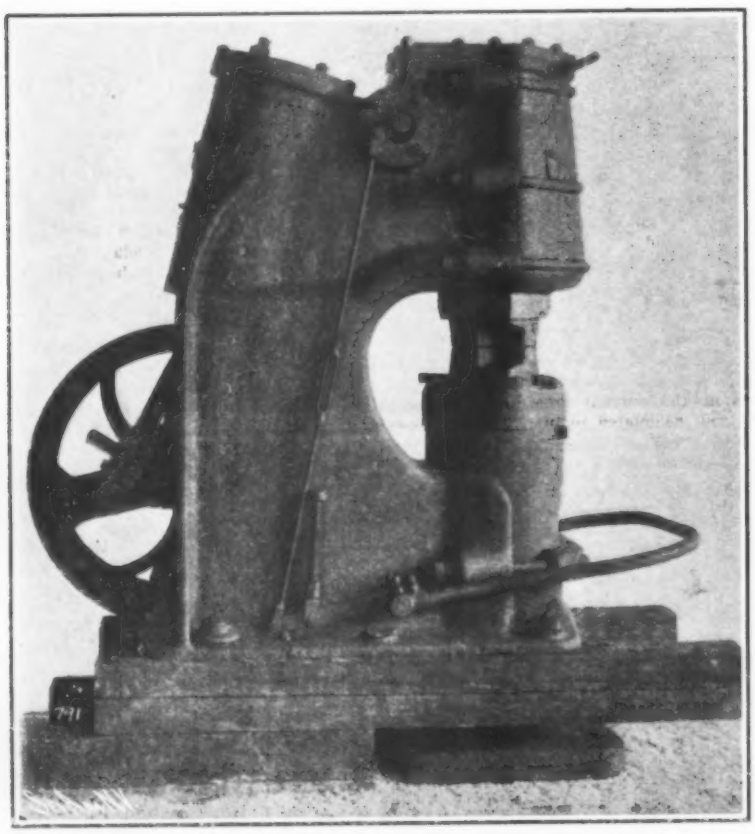
Many electrically-driven pneumatic hammers of American construction as well as those built in England and Germany are also belt-driven machines, the power being taken from an ordinary countershaft. It is stated that when this English power hammer is belt-driven, the fast and loose pulleys of the countershaft are mounted on the extension of the base plate, and the large spur wheel is driven by means of a pinion, the driving pulley also being a flywheel. It is held that this arrangement keeps the countershaft self-contained with the hammer, and allows a high-speed belt drive to be utilized.

A new German hammer of similar construction, with belt driving, has been constructed at Aerzen, Hanover. The speed of this hammer is 105 meters per minute with a pressure of 8 atmospheres. An electric motor of 15 horse-power is utilized, and the number of strokes per minute is 150. The total weight of the pneumatic hammer is 9,800 kilogrammes (21,605 pounds) and it is designed to take material 170 square millimeters (0.26 inch) in cross section with a height of stroke of 265 millimeters (10.4 inches). Many of these German pneumatic hammers are of much larger capacity, and are said to accomplish the work to better advantage than steam hammers.

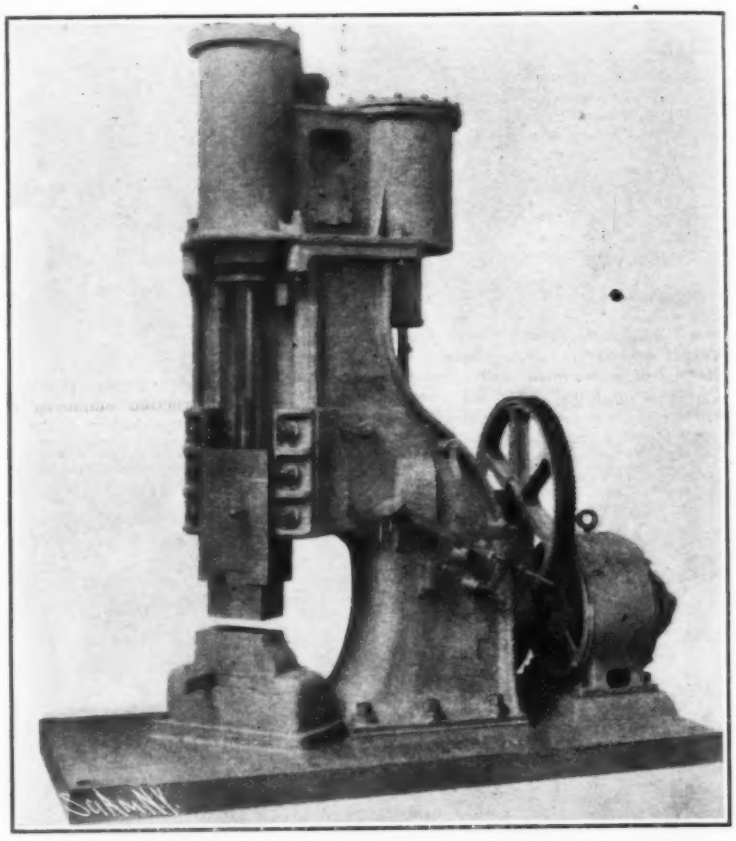
Another interesting type of electrically-driven pneumatic hammer of German design is that shown on the front page, which operates with a three-phase alternating-current motor. The above-mentioned English and German hammers were driven by direct-current motors, but on account of the many advantages of alternating-current machines for long-distance distribution, it is interesting to note this type of hammer driven by an alternating-current machine. The current is supplied from three overhead conductors carried down to the base of the machine through iron conduits and to the controlling mechanism and motors by three cables, also installed in conduits on the frame of the machine. The motor has three collector rings, with the contact brushes below in the form of a V. The motor is geared to the countershaft, and is mounted on a bracket at the upper portion of the frame of the hammer, a large flywheel being provided on the opposite side of the hammer and counterbalancing a large gear wheel. The illustration shows the hammer ready for operation, with an attendant holding the forging ready for a blow, while the operator controlling the motor stands back of the hammer.

Pictured in one of the illustrations is an American 250-pound Yealey hammer controlled by a lever in front. Electric power may be utilized to advantage with so many forms of machine tools at the present time, that great attention is being paid to the direct connection of electric motors to the machines as the most approved practice in machine design.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.



AN AMERICAN TWO-HUNDRED-AND-FIFTY-POUND HAMMER.



A TWENTY-HUNDREDWEIGHT ELECTRICALLY-DRIVEN HAMMER.

METALLIC FILAMENTS FOR ELECTRIC LAMPS.

IT is now quite well known that several metals are infusible enough to serve as lamp filaments if they can only be made into that form. The infusibility of the metal is the chief obstacle to its being made into wire, for such metals are generally obtainable only in a fine powder by reduction from the oxide, or in partially fused lumps which contain carbon, and are not in a condition suitable for wire drawing.

Dr. Hans Kuzel has invented a process by which the most refractory and obstinate metals can be made into filaments. It might be said that there is little difficulty in making a filament from a metallic powder by mixing it with an agglutinant and squirting it. Anyone who has tried squirting such things as powdered silicon, tungsten, or molybdenum will realize the difficulties. Tungsten powder, for instance, can be squirted in rods about a millimeter in diameter; but these would be of no use for resistance in thousands of ohms. These powders, made into pastes and squirted, generally pack, and only water comes through the nozzle. Squirting can be greatly facilitated by the use of gum tragacanth. It would be interesting to know who first thought of tragacanth in that connection. A comparatively small percentage of the population of the globe knows anything about tragacanth or its ways; and a still smaller percentage is interested in squirting filaments; so that the chances that any one person, knowing about tragacanth and wanting to squirt filaments, should realize that tragacanth would help him are very small indeed. I believe the use of this gum was due to Farnejehlm—one of the early workers in incandescent gas light. He made mantles of little baskets of squirted magnesia.

Kuzel is generally supposed to have invented a tungsten lamp. His invention is really a method of making lamp filaments of any suitable metal; and he appears to have chosen tungsten as the most suitable. He makes what he calls "hydrosols, organosols, gels, or colloidal suspensions." It will be remembered that Bredig prepared what is called "colloidal" platinum by making an arc between platinum electrodes under water. Apparently the platinum vapor condenses in the water in the form of very fine particles, and the resulting liquid is said to contain colloidal platinum. Kuzel makes colloidal chromium, manganese, molybdenum, uranium, tungsten, vanadium, tantalum, niobium, titanium, thorium, zirconium, platinum, osmium, iridium, boron, and silicon; I am quoting from his patent specification. No doubt Kuzel has experimented on all these. Of course, I have not.

Whether such a process really gives metal in a colloidal form is a matter rather of scientific than of commercial interest. The exigencies of journalism do not give a writer time to look up the scientific literature of a subject. This is a great advantage from his point of view as he can be inaccurate with a clear conscience. I have, therefore, been unable to refer to Bredig's paper; but by a "colloidal" substance is generally meant such a substance as gelatine, which appears to exist in solution in large particles, if such an expression can be used. What is known as "colloidal gold," on the other hand, may be merely gold in very small pieces floating about in a liquid. The particles are too small to be seen properly through an ordinary microscope; but recently an advance has been made in microscopy by means of which the existence of small particles in colloidal gold solution can be seen. I am sorry I cannot remember the name of the inventor of this system; one of his microscopes was shown at the Physical Society lately by Messrs. Zeiss or Beck, with some colloidal gold for examination. It may be said that if the gold is in small particles it would settle, and it would not pass through filter paper. But fine precipitates will pass through filter paper. Ink, or better still, India ink, is a good example. If ink is examined under a microscope it will be found that the particles are all moving about with immense activity; and this is probably the reason why they do not settle. Very little work has been done in studying this "pedesis" or "Brownian" movement, as it is called. The addition of certain salts to water containing finely-divided ferric oxide, for instance, stops the rapid motion, and the particles group themselves together and descend as a flocculent precipitate. Bredig urged that his colloidal platinum acted as an inorganic ferment in many cases. It is quite possible, however, that the fineness and movement of the particles had much to do with it, and that the "poisoning" of the platinum was intimately connected with the stopping of its pedesis. Whether Kuzel's finely divided metals should be called colloidal suspensions, gels, or hydrosols is for the present purpose a side issue. The fact appears to be that he has invented a most ingenious way of converting metals into a fine, smooth paste, in which the particles are so exceedingly small that very fine filaments of paste can be squirted. These filaments are then heated electrically until they practically fuse together.

If this invention works practically, as there is little doubt it does, it opens a very large field, because it puts the inventor in the position of being able to make lamp filaments of any metal he chooses. It is simply a matter of choosing one which has a high melting point, and is otherwise convenient. Of course, the melting points of the very refractory metals are not yet ascertained. It has been known for a long time that tungsten is very infusible; and it was considered

an achievement when it was first fused in the electric furnace some fifty years ago. The metal is otherwise so unpromising physically that to make from it a lamp filament is a very remarkable triumph over the apparent obstinacy of inanimate things.—J. Swinburne, Past President Inst. E. E., in The London Times Engineering Supplement.

IS THE SIXTEEN CANDLE-POWER STANDARD FOR ELECTRIC LAMPS OUT OF DATE?

THE Electric World in a lengthy editorial contends strongly that the sixteen candle-power lamp as a standard unit is behind the times, and that it is bound to be superseded in the near future by higher units. Illuminating engineers, however, do not seem to be unanimous in accepting this view of the case. When the matter was mentioned at the recent meeting of the Illuminating Engineering Society, President Marks emphatically placed himself on record as opposed to the idea; and although no further discussion of the matter followed, it was apparent that there was much sympathy with his position among the members present.

That there is a general tendency toward the using of higher units is plainly evident from the facts. So far as there is genuine competition between gas and electric light, the contest is usually to see who can produce the greatest flood of light for a given expenditure, entirely regardless of the visual and æsthetic qualities of the illumination produced. The incandescent gas burner, with its fairly dazzling light of 60 rated candle-power, or more, could only be beaten by a cluster of the standard sixteen candle-power electric lamps, or the electrical arc. To compete with the latter the "gas arc" was produced, which was simply a cluster of incandescent mantles. At last accounts electric lighting had scored a complete victory by the introduction of the flame arc, which has left the gas arc and all other forms of illumination hopelessly behind in the race for garish brilliancy.

In many respects the contest reminds one of the country band tournament, in which the band that made the most noise won the prize. Increase in light power by closely clustering small light units has usually and rightfully been condemned by illuminating engineers; and the most serious fault of the arc lamp has been its necessarily high light-power as well as high intrinsic brilliancy.

As to the value of illuminating engineering, the editorial referred to says: "In fact, the conditions are such that illuminating engineering is becoming an important art, not so much because of what its practitioners can accomplish with respect to the design of illumination along ideal lines, as in getting the best results with conditions everywhere conflicting with the ideal." In one sense this view is a true one. The value of the illuminating engineer at the present time, and possibly for some time to come, will be largely measured by his present ability and ingenuity in correcting the outrageous blunders that have been made in laying out illuminating systems heretofore. "Conditions conflicting with the ideal" is truly a very mild way of describing them. They more generally conflict with common sense, with the most obvious principles of illumination, and with the accepted canons of artistic taste; and the illuminating engineer who can bring a semblance of order out of this chaos is worthy of due praise—as well as his fee.

But in that department of work which deals with the planning of new installations there is no more reason for "conditions conflicting with the ideal" hampering or restricting the free play of his judgment and skill than there is for their interfering with the plans of the architect or electrical engineer. Outlets properly located are not usually any more expensive than those located by guess; in fact, the contrary is rather the case. Good illuminating engineering will ordinarily reduce wiring cost, but it is one of the anomalies of the general lavishness with which buildings are constructed in this country that a few dollars difference in original cost in the lighting installation is allowed to seriously reduce the efficiency of the illumination produced, and so produce an operative tax continuing as long as the installation is in use.

There are usually several ways of producing practically equally good illuminating results, and the illuminating engineer must be sufficiently conversant with wiring principles and pipe fitting to select the one which can be installed at least expense; but, to knowingly reduce the efficiency of the illumination in order to make what can at best only be a trifling reduction in the cost of installation is simply a case of "saving at the spigot and wasting at the bung."

There are undoubtedly many cases where multiple lights, either in clusters or in chandeliers, can be very advantageously replaced with the more efficient units that are coming into use, but the ordinary dwelling house certainly does not afford such a case. While the general race of each to outshine his neighbor is interesting along "the Great White Way," there are few who wish to carry the contest into their private apartments; the rest and eye comfort resulting from a soft and comparatively low intensity of illumination are still demanded for the home. The chandelier with multiple lights, or the cluster, has the advantage of affording a variable illumination, and on this account alone must always take precedence over the single unit of high power for private lighting.

"The craving for brighter artificial illumination" may not yet be satisfied, it is true, but if the only effect of the more efficient lamps which are making their appearance is to result in nothing more than a stimulation of this craving, their advent will be of very questionable advantage to the cause of good illumination. In one point at least their use is a distinct menace to the best illuminating effects, viz.: their excessive intrinsic brilliancy; and it will be within the province of the illuminating engineer to see that this defect is counteracted by the use of proper methods of diffusion, and that the excessive general brilliancy is not produced simply because it can be at no greater outlay of money. If there is one principle in the confessedly imperfect science of illuminating engineering that is generally accepted, it is that the tendency to excessive brilliancy is a more common fault at the present time than insufficient light, and that a better distribution and more complete diffusion of the light used are the two improvements most often demanded. Neither of these reforms can be furthered by discarding the present 16 candle-power standard in favor of high power units.—The Illuminating Engineer.

THE FIREPROOF DYNAMO.*

THE weak point in electrical machinery is almost always the insulation. It is true that the direct-current dynamo is somewhat handicapped by its commutator, but improved design has reduced the troubles at this point very greatly, and the commutator itself may be constructed so as to withstand a great deal of hard service. But both alternating and direct-current machines must employ some insulating material, and this is generally of necessity of such a character that it is seriously damaged, if not destroyed, by overheating. The commonest insulating materials are cotton and flax, which become carbonized at temperatures not much above that of boiling water, and they thus lose the very property for which they are used. In larger machines or those constructed for exceedingly high voltages the cotton insulation may be supplemented or even replaced by other materials, such as tubes of fiber or of mica. But fiber and even the cement used for building up tubes of small pieces of mica cannot withstand indefinitely high temperatures, so that a form of construction which does not become too hot must be adopted. By means of various devices, such as ventilating systems or ways of arranging the materials of the machine, it is possible to dissipate a great deal more energy from a given weight of material or from a given surface than we could a few years ago. In this way we have succeeded in decreasing the weight and the cost of our apparatus, but we are not yet independent of temperature, for an overloaded machine will still become dangerously hot.

The difficulty encountered in insulating electrical machinery lies in the fact that a good electric insulator is also a good heat insulator, and the very process of construction employed to prevent the current from taking undesired paths is one well calculated to prevent the dissipation of heat, and therefore the inner layers of a winding of insulated wire in which energy is being dissipated as heat will be at a temperature considerably higher than that of the outer layers. One of the most successful means of combating this difficulty is the use of ventilating ducts, which cause a circulation of air through the machine. Another, of more recent date, also of very great importance in the construction of machines, is the use of the strip windings. By this means a coil having a sufficient number of turns, with a conductor of the proper cross-section, may be made but one layer deep; and when this conductor is bare, as is very frequently the case, every foot of it is exposed to the air. This solution may be compared with the lamination of the armature core. A good path for heat conduction is provided, but a poor path for electrical conduction across from layer to layer, just as in the injury from overheating. The coils, after being wound, may be saturated with some insulating material and baked so as to convert them into a solid mass. This method of treatment has been employed in various ways, but has not come into general use for windings, and though of considerable value, this method would not make a machine entirely fireproof, for the insulation of the wire will eventually break down under the continued high heat, resulting possibly in a short-circuit.

Another method of insulation more recently tried makes use of the insulating property of aluminium oxide. This metal is used instead of copper, and is treated so as to take on a coating of oxide. The wire thus treated—otherwise bare—is wound up in coils without any other provision being made for insulation. For high voltage some precautions are necessary to secure a sufficiently thick coating of the oxide, but for ordinary voltages no treatment at all is required. The advantage of this method, beyond the reduction in cost which is said to result from it, will lie in the fact that the insulating coating is thin, and there is but little space not filled by the metal. If square wire be employed, as suggested, in some cases, the coil becomes almost a solid mass of metal and oxide. Such a coil is not only able to withstand fairly high temperatures, but should be a fairly good dissipator of heat, for although the insulating coating is itself a non-conductor, the fact that there is but little air space left between adjacent wires would facilitate the conduction and dissipation of heat. It is a question whether a coil wound in this way could stand very high temperatures, such, for example, as would drive off the water of crystallization of the oxide coating. Even should this happen, the pure oxide might be a fairly satisfactory insulator. The ideal construction is one which would enable the coils to be used even if red hot, although, of course, other considerations make it undesirable to work at such temperatures. The question of efficiency is an important one, and this is bound up in that of temperature.

* From the Electrical Review, New York.

IMPROVEMENTS IN GAS LIGHTING.*

IN our last month's issue we traced briefly the recent improvements in the means of producing light electrically, and expressed the opinion that these improved methods were so far in advance of those in present use as to be revolutionary in their effect. From the fact that little progress had been made in electrical lighting for a decade or more, the comparatively sudden appearance of a number of almost startling discoveries created all the more profound impression, and for the time being, at least, has rather eclipsed the steady, if less spectacular, advancement that is taking place in gas illumination.

The inverted gas burner was hailed with delight by gas engineers as supplying a means of meeting a phase of electrical competition which had previously been difficult, and in many cases impossible, to meet; viz., the greater adaptability of the electric lamp, and the wider range of decorative effects which it made possible. But, even among those particularly interested in gas illumination, there have been misgivings and doubts as to the ultimate success of this form of burner.

The inverted burner first came into public use in Europe, where conditions are somewhat different than in this country; and there is no doubt that these differences have been sufficient in many cases to counteract to a considerable extent the advantages which the burner possessed in its native field.

The conditions here, however, which have interfered with the utility of the inverted burner, are apparently reducible to two, viz., the supply of gas at a lower pressure, and poor regulation. These two conditions, it would seem, are sufficiently easy to adjust, if any material advantage is to be gained thereby. In other words, if a slightly higher pressure and better regulation is all that is needed to make the inverted burner the success which is claimed for it by the makers, and by many gas engineers, there would seem to be little excuse for not complying with these conditions in this country.

The inverted burner has already led to a series of types following still more closely the adaptability of the electric lamp. Burners have been produced to burn at an angle downward, to burn horizontally, and even capable of being inverted at will, so as to burn either in the upward or downward position.

As eminent an author as Dr. Drehschmidt, of Berlin, commits himself enthusiastically to the advantages of this form of burner, as will be seen by a perusal of his recent paper on the subject, a translation of which appears in another section. Our London correspondent in the field of gas illumination, Mr. Charles W. Hastings, editor of the Gas Engineer's Magazine, London, also reports the continuous increase in popularity and use of the inverted burner and kindred forms of gas light.

The use of "intensified" burners, i. e., of burners in which either gas or air is supplied at pressure above the normal, of which we have also previously spoken, are already a commercial factor in Europe, and are likely to become so in this country as well. We have information from a private source that an American inventor has developed successfully a process of mechanically mixing gas and air before it is supplied to the mains, and it is claimed that such a mixture burned in the best burners will give an efficiency of above 90 candles per cubic foot.

With the marked increase in efficiency resulting from the methods mentioned, and with the admittedly greater artistic possibilities of the inverted burner, it will readily be seen that gas is not at all likely to fall far behind its present position in the field of illumination, at least not so long as the generation of electricity requires the use of fuel in engines of the present type. Should some inventor, however, discover the long sought means of securing an electric current directly from the potential energy of coal or other fuel, all predictions would have to be revised. But unless this occurs gas lighting is pretty sure to continue to hold its present position for many years to come.

* The Illuminating Engineer.

"OUNCE METAL."

A BRASS foundry mixture known as "ounce metal" has been used for a long time as one of the standard mixtures. It is a very satisfactory one for general purposes where a good color is desired and a stiff metal which turns freely. It is used quite extensively for the manufacture of valves, although it cannot be called the best steam mixture. It contains too much lead and not enough tin for such a purpose.

The mixture for ounce-metal is as follows:

Copper	1 lb. or	85 per cent
Tin	1 oz. or	5 per cent
Zinc	1 oz. or	5 per cent
Lead	1 oz. or	5 per cent

The name "ounce metal" is derived from the fact that an ounce each of tin, zinc, and lead are used to one pound of copper. For general work it is supposed to be next to "composition" in quality. For work which requires a little better grade of metal than "composition" and of a better color, "ounce mixture" will be found quite suitable. It is really the intermediate mixture between "steam metal" and "composition." It is satisfactory for ordinary valve work.—Brass World.

HOW TO CONSTRUCT AN INDEPENDENT INTERRUPTER.*

By A. FREDERICK COLLINS.†

IT is usually not an easy task that confronts the amateur constructor of a large induction coil when he reaches a point in his work where he must choose the type of interrupter he intends to use.

While the mercury turbine and electrolytic interrupters are a great deal more effective than a vibrating spring interrupter of the best type, yet the former devices are more complicated and require constant attention. The independent multiple interrupter is the next best instrument and, indeed, many operators prefer it, for, while the highest efficiency is not secured by its use, it possesses the compensating features of being simple, always ready, requires practically no attention in adjustment, and gives excellent results. Moreover, it may be applied to coils of all sizes giving a four-inch spark or over, and can be operated on a battery or 110-volt direct-current circuit with equal facility.

The term "independent multiple interrupter" is used to indicate that this make-and-break device is complete in itself, although it forms a subsidiary piece of apparatus of the completed coil. In the type under consideration a vertical rod is secured to the free end of the shunt-circuit vibrating spring, and this carries a sliding weight retained in position by a set screw; by moving the weight along the rod the period of vibration may be varied within certain limits; hence the word "multiple" is used to distinguish it from those interrupters whose periods of vibration are fixed.

The independent interrupter to be described embodies all the improvements of the double spring interrupter, and being operated by a shunt circuit it may be started or stopped as desired and the current flowing through the primary coil made or broken or intermittently interrupted, as the specifications of some wireless telegraph systems call for. Other good points in favor of this interrupter are, that its action is independent of the heavy current flowing through the coil, it gives a clean-cut and exceedingly sharp break, and it cannot stick.

The individual parts of the independent interrupter are shown in Fig. 1, the sizes of which may be obtained by referring to the following table.

When all the above parts have been prepared the interrupter is ready to be assembled. To one end of the main contact spring, which is the thin one (see Figs. 2 and 3), the iron plate is secured by means of a ¼-inch screw and a nut 3/16 inch thick; the length of the screw is such that the nut projects 3/32 inch over its end and into this is screwed and soldered the platinum contact point. A small screw passes through the spring and into the plate to keep the latter from turning; this leaves the end of the plate with the large hole projecting above the end of the spring, while the opposite end is screwed to its brass support and the latter to the hard-rubber base; it should be set at a distance of 2¼ inches from one end of the latter and 1½ inches from either side.

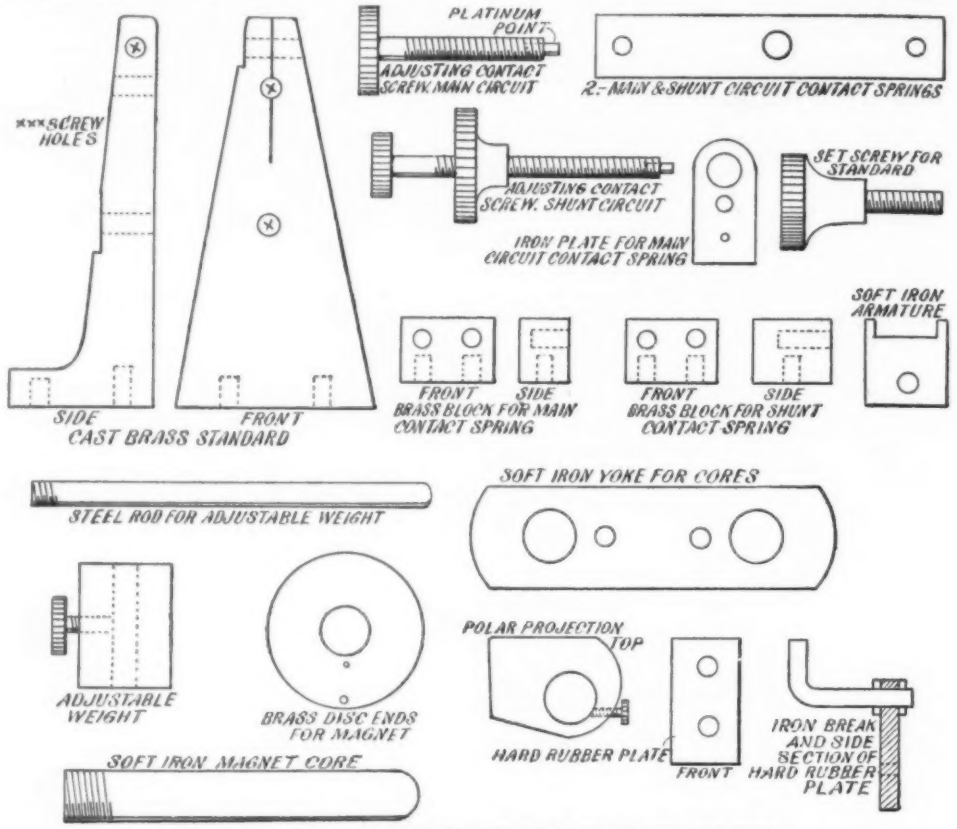


FIG. 1.—PARTS OF THE INDEPENDENT INTERRUPTER.

The shunt circuit spring, which is the thick one, is placed in the groove of the cubical armature and on the opposite side of the spring, and likewise mounted in the groove with it is the hard-rubber plate when the three pieces are screwed together. The bent iron break rod with a stop nut screwed on it 5/16 inch is then inserted through the upper hole in the hard rubber plate, which projects above the armature, and this is rigidly attached by a nut on the opposite side. In the top of the armature is screwed the brass rod for carrying the adjustable weight. The lower end of the spring is then screwed to its brass block support and the latter in turn to the hard rubber base, when the spring should set ½ inch in front of the shunt circuit

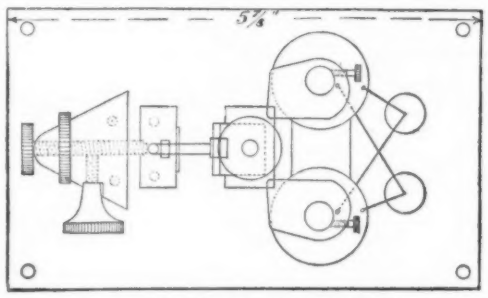


FIG. 2.—PLAN OF INDEPENDENT INTERRUPTER.

spring or 2¾ inches from the front end. To the screw holding the support of the spring to the base a few inches of insulated wire, about No. 16, is connected, as this is a portion of the shunt circuit.

The standard is secured to the base by two screws, and the face of this should be exactly ½ inch back of the main circuit contact spring or 2 inches from the front of the base. To one of the screws underneath the base a No. 12 insulated wire is attached having

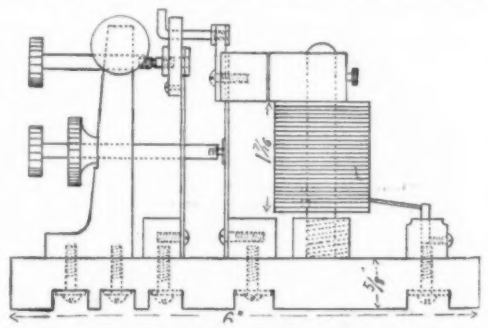


FIG. 3.—SIDE ELEVATION OF INDEPENDENT INTERRUPTER.

a length of several inches, for both the main and shunt circuits currents pass through it. Into the extreme upper hole on the side of the standard the set-screw is inserted and in the hole just below and at right angles to it is screwed the adjusting contact screw of the main circuit break. Into the lower hole

TABLE OF SIZES OF INTERRUPTER PARTS.

1	Cast Brass Standard	Height 3 ins.	Dimensions front and rear elevations top ¼ in.	Dimensions front and rear elevations base 1⅜ ins.	Dimensions side elevation top ⅝.	Dimensions side elevation base 1¼ ins.	⅛-in. hole drilled and tapped from face to back ⅛ in. from top. Ditto 1½ in. from base; ⅛-in. hole drilled and tapped through on side ¼ in. from top. Three ⅛-in. holes drilled and tapped in surface of base.
2	Adjusting contact screw for main circuit	Length ⅛ in.	Diam. ⅛ in.	Diam of milled head ⅝ in.	Diam. of check nut ⅞ in.	.....	End drilled and tapped out and platinum point screwed in.
3	Platinum contact points for adjusting screws	For main circuit scr'w diam. 1/16 in.	For main circuit scr'w length ¾ in.	For shunt circuit scr'w diam. 1/16 in.	For shunt circuit scr'w length ⅛ in.		
4	Adjusting contact screw for shunt circuit	Length 2¼ in.	Diam. ⅛ in.	Diam. of milled head ⅛ in.	Diam. of check nut ⅜ in.		
5	Main circuit contact spring	Length 2¼ in.	Width ⅛ in.	Thickness 1/16 in.	.....	.....	⅛-in. hole drilled and tapped ¾ in. from each end; ¼-in. hole cut out 1⅛ in. from bottom.
6	Iron plate for main circuit contact spring	Length 1 in.	Width ⅛ in.	Thickness 1/16 in.	.....	.....	Rounded top; ¼-in. hole drilled ¼ in. from top; ⅛-in. hole drilled and tapped ⅛ in. from top; ⅛-in. hole drilled and tapped ⅛ in. from bottom.
7	Set screw for standard	Length of screw ⅝ in.	Diam. of screw ⅛ in.	Diam. of milled head ⅜ in.	Total length 1¼ in.	.....	Screw is turned with a shoulder.
8	Shunt circuit contact spring	Length 2¼ in.	Width ⅛ in.	Thickness 1/16 in.	.....	.....	⅛-in. hole drilled ¼ in. from each end; platinum contact disk soldered to spring 1⅛ in. from bottom.
9	Brass block for main contact spring	Length ¾ in.	Width ⅛ in.	Thickness ⅛ in.	.....	.....	⅛-in. hole drilled and tapped in center of side. Ditto in bottom.
10	Brass block for shunt contact spring	Length ¾ in.	Width ⅝ in.	Thickness ⅛ in.	.....	.....	⅛-in. hole in side and bottom as above.
11	Soft iron armature	Length ⅝ in.	Width ⅝ in.	Thickness ⅝ in.	.....	.....	Slotted to depth ¼ in. on one side ⅛ in. wide to receive spring; ⅛-in. hole drilled in center of slotted side; ⅛-in. hole drilled and tapped in top ⅛ in. of edge opposite slot.
12	Steel rod for sliding weight	Length 3 in.	Diam. ⅛ in.				
13	Sliding weight	Length 1 in.	Diam. ¾ in.	.....	.....	.....	⅛-in. hole drilled longitudinally through center; ⅛-in. hole drilled and tapped at right angles to above hole; this is for set screw.
14	Soft iron magnet cores (2)	Length 2¼ in.	Diam. ⅝ in.	.....	.....	.....	One end threaded; opposite end rounded.
15	Brass disk ends for magnet cores (4)	Outside diam. 1¼ in.	Diam. of aperture ⅝ in.	Thickness ⅛ in.	Distance from core ends, tapped end ⅝ in.	Distance from core ends, rounded end ¾ in.	⅛-in. holes drilled in two lower disks; first within ⅜ in. of aperture, second same distance from circumference.
16	Soft iron yoke for cores	Length 2¼ in	Width ¾ in.	Thickness 1/16 in.	.....	.....	Holes drilled and tapped ⅝ in. from each end to receive magnet cores; ⅛-in. holes near middle of screw yoke to base.
17	Polar projections	Length 1 in.	Width from ⅝ in at polar end to ¾ in. at rounded end.	Thickness ⅛ in.	Cross section of polar ends ⅝ x ⅝ in.	.....	⅜-in. hole drilled through from top to bottom; ⅝-in. polar end; ⅛-in. hole drilled and tapped for set-screw in rounded end.
18	Magnet wire double cotton covered	No. 28.	Amount in ounces (approx.) 6	Number of turns (approx.) 1300			
19	Hard rubber plate for armature and shunt circuit	Length 7/16 in.	Width ¼ in.	Thickness 1/16 in.	.....	.....	⅛-in. hole drilled ⅜ in. from bottom; ditto ⅛ in. from top.
20	Iron break rod	Length ¾ in.	Diam. ⅛ in.	.....	.....	.....	Bent up ¼ in. from one end. End of longest portion threaded.
21	Hard rubber base	Length 6 in.	Width 3⅛ in	Thickness 1/16 in.			

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

† Copyright 1906 by A. Frederick Collins.

the adjusting contact screw is inserted and screwed in so that it passes through the aperture in the main spring (but care must be taken that it clears the spring or otherwise the interruptor will be short-circuited) until it makes contact with the platinum disk soldered to the shunt circuit spring.

The yoke of the magnet is screwed to the base, it being assumed that the magnet coils have been wound. It may here be said that if double cotton-covered magnet wire is used there is no necessity for shellacing the layers. The cores of the magnet are screwed into the yoke and the polar projections slipped over the upper ends of the cores which should be adjusted so that when the spring carrying the armature is drawn to the cube of soft iron joining it, it will pass without touching either of the poles between them. This precludes the possibility of the armature sticking.

The binding posts are screwed into their respective holes in the end of the base, and from these underneath are connected terminals of No. 16 insulated wire. The terminals of the magnet between the coils and the posts are protected by rubber tubing and are connected in parallel instead of in series so that both ends of each coil are brought out and the two outer ends are connected to the posts nearest them while the two inner ends are crossed over and connected to the posts.

The interrupter is now ready to be connected with the inductor and source of electromotive force. Fig. 4 shows how these connections are made. The circuit from the battery or main line is led to the standard, the opposite side making connection with the thin spring carrying the heavy platinum points through

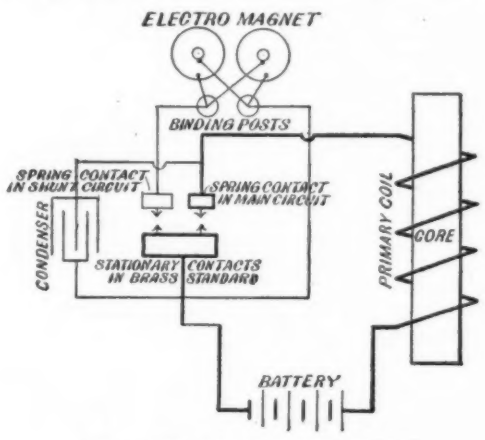


FIG. 4.—DIAGRAM OF CIRCUITS.

the primary winding of the coil. A shunt circuit leads off from the opposite side of the source of current, as shown in the diagram, and this includes the magnet coils and the light platinum contact on the heavy spring, the circuit being completed through the stationary contact carried by the lower screw of the standard.

The operation of the independent interrupter is simple. When the main and shunt circuits are open the movable and stationary contacts of both are closed; but when the current is turned on the magnet begins to pull the armature to its poles and by the time its cycle is one-fourth completed the bent end of the iron break rod attached to it strikes the iron plate of the main contact spring with the full force acquired through the pull of the magnet and its momentum, this action precluding the possibility of the platinum contacts striking, due to the welding of their surfaces by the heavy current. When the armature has pulled the shunt circuit contacts apart the elasticity of both springs brings the contacts together again, while the armature with its added weight above overshoots its normal vertical position, which on the return stroke again breaks the contacts.

To obtain the best results an adjustable condenser should be used in connection with the independent interrupter and is an important element in the proper working of the instrument, since different periods of interruption require varying values of capacity. For 10 and 12-inch coils mica condensers having a total capacity of 4 or 5 microfarads subdivided into fifths or tenths, preferably the latter, should be used, so that a suitable value may be had for all the different rates of interruption that the adjustable weight is capable of giving.

EXPERIMENTAL THEATER CONFLAGRATIONS.*

SOME very interesting experiments have been made in Vienna for the purpose of studying the phenomena of fires originating on the stage of a theater and determining the best methods of safeguarding the audience.

The experimental theater was constructed of steel concrete. The stage building is about 25 feet wide, 20 feet deep, and 25 feet high; the proscenium arch, 12 feet wide and 8½ feet high. Across the front of the stage extends a yard wide passage, separated from the stage by a wall having a large opening which can be closed by the ordinary drop curtain, and from the auditorium by a similar wall and the iron fire curtain. The stage has three doors communicating with the outer door, one at the back and one at each end of the passage. It also has four upper windows. In the center of the roof of the stage is a smoke outlet measuring about 3 by 8 feet, and in each corner is a sort of chimney, the combined area of the five openings being about one-eleventh the area of the stage.

The auditorium is 18 feet wide, 23 feet deep, and 15½ feet high. It communicates directly with the open air by a door on each side, near the stage. At the back is a gallery with a door at each end opening on external stairs. The back of the parterre, under this gallery, is separated from the front portion by a partition of steel concrete and wire glass behind which the observers of the experimental conflagrations can stand in safety. This observation chamber has a door opening on the street and another communicating with the body of the auditorium. In the roof of the auditorium is a smoke outlet about 3 feet square.

The theater is lighted by gas, candles, ordinary kerosene lamps, safety lamps, and electric bulbs.

In preliminary experiments automatic registering apparatus has indicated a maximum temperature of 750 deg. F. above the stage and maximum excesses over barometric pressure equivalent to 6.3 inches of water in the stage building and 5.5 inches in the auditorium when the curtains were raised, but all other openings in the auditorium were closed. This increase of pressure shattered the windows over the stage, and the glass was replaced by sheet iron. The pressure also raised the two valves of the cover of the smoke outlet in the roof of the stage, weighing 175 pounds each, but it did not prevent the perfect working of the iron curtain. Two small air holes in the walls near the floor of the stage facilitated a rapid spread of the fire.

After twenty-seven preliminary experiments had been made, the final experiments, five in number, were performed on November 22, 1905, in the presence of a committee of the Austrian Society of Engineers and Architects and a number of invited guests, including Count Kielmansegg, governor of the province of Lower Austria, through whose influence a grant of 12,000 crowns ($2,436) had been obtained from the imperial treasury for the prosecution of the work.

A quantity of "scenery" was provided, made of lath and paper soaked in a fire-retarding compound, with which the drop curtain was also impregnated. The chief fuel consisted of kindling wood which, together with the curtain and scenery, was saturated with petroleum. The fires were extinguished by a Vienna fire company armed with spraying nozzles, and in the last experiment an automatic Grinnell sprinkler over the stage also came into play. The conflagration could be watched from the observation chamber at the back of the auditorium and also through small windows, covered with fire-resisting glass, in the walls of the stage building.

The little experimental theater differs from real theaters in having no exterior corridors or lobbies. All the doors lead directly to the open air so that there is a strong indraft of cold air when they are opened. The fire, too, kindled more quickly and explosively than accidental fires usually do.*

First Experiment.—The conditions were made very unfavorable. All the outlets of the stage building were closed, while the outlet in the roof of the auditorium was half open. The drop curtain was down, the iron fire curtain raised. Gas, candles, kerosene, and electric lamps were lighted.

The burning of the combustible material on the stage developed, rapidly and explosively, a pressure which blew the bottom of the curtain far out into the auditorium. The insufficiency of air caused the combustion to be incomplete, and dense opaque smoke filled the auditorium as well as the stage. Burning fragments of wood and of the curtain were carried by the draft to the back of the auditorium. The increased atmospheric pressure, exceeding the pressure in the mains, at once extinguished the gas jets, and the deficiency of oxygen soon smothered the candles and kerosene lamps. The electric lights continued to glow, but their light was so obscured by the smoke that an audience would have been unable to find the exits and would certainly have been suffocated.

The observers of the experiments stood in the observation chamber, behind the fireproof partition.

Second Experiment.—The conditions remained as before, except that there was no inflammable curtain and the iron curtain was lowered after the fire on the stage was well started. As the smoke and gases could not escape in any other way they poured into the auditorium under the fire curtain in a stream that increased in force as the curtain descended, so that finally a jet of flame, 10 feet long, protruded into the auditorium, accompanied by a shower of blazing splinters. These phenomena ceased when the bottom of the iron curtain reached the stage. As before, the observers stood behind the partition.

Third Experiment.—Both curtains remained raised and the outlet in the auditorium tightly closed, while all the outlets in the roof of the stage were opened immediately after the fire was started.

These outlets carried off the smoke so well that none entered the auditorium where the observers stood in front of the fireproof partition, in perfect safety, though somewhat inconvenienced by radiated heat.

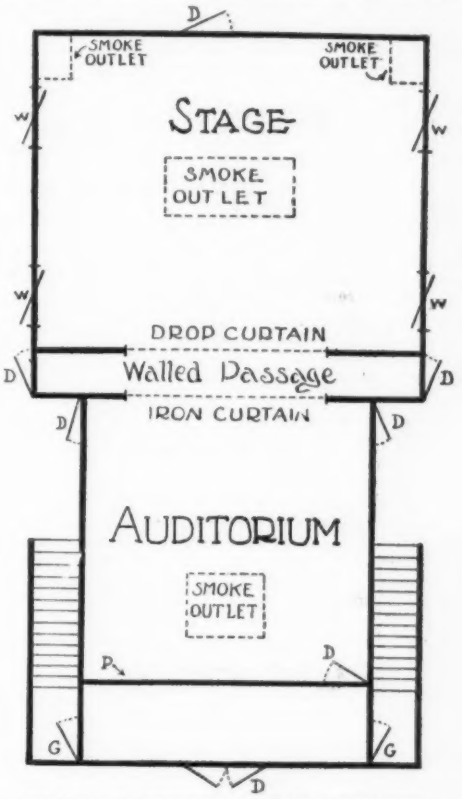
Fourth Experiment.—The smoke outlet over the auditorium remained closed, but the stage outlets were opened in the course of the conflagration, partly by hand and partly by the burning of combustible fastenings. The iron curtain was lowered after the fire was started. The observers stood in front of the partition and suffered little from heat, as the curtain cut off the radiation before the fire had made much progress. The other phenomena were the same as in the third experiment.

These results appeared to confirm the conclusions to which the committee had been led by the preliminary experiments, namely, that the opening of the outlets over the stage was the all important means of protection and that it should be accomplished as promptly as possible and even before the lowering of the iron curtain, in order to prevent the strong indraft of smoke and flame through the narrowed opening below the descending curtain. (See second experiment.)

Some of the spectators, however, dissented from this view. They pointed out that the opening of the outlets would fan the flames and thus precipitate a panic in the audience if the fire curtain were not down, and furthermore that in an actual theater conflagration all the doors of stage and auditorium would be immediately opened and the inrush of air would drive the smoke into the auditorium. These objections led to the making of the fifth experiment.

Fifth Experiment.—The outlet over the auditorium remained closed while the outlets over the stage and all the doors of both stage and auditorium were opened at the beginning of the conflagration. The iron curtain was not immediately lowered.

The result fully sustained the objections above quoted. The outlets carried off the smoke of the incipient fire, but as soon as the doors were opened smoke, flame, and burning fragments rushed into the auditorium so fiercely that those of the observers who had rashly taken their stand in front of the fireproof



PLAN OF EXPERIMENTAL THEATER.

W. Windows over stage. *D.* Doors on ground floor. *G.* Gallery doors leading to outside stairs. *P.* Partition of steel-concrete and wire-glass.

partition were saved from serious injury only by the prompt lowering of the iron curtains.

From all these experiments the writer draws the following conclusions:

1. Every theater should have a quick-acting and reliable iron curtain of sufficient thickness, which should be dropped instantly if there is the slightest doubt that a fire occurring on the stage cannot be extinguished at once.

2. Over the stage, if possible at the highest points of the roof, there should be smoke outlets of an aggregate cross-section equal to at least one-eighth and preferably one-fifth of the area of the stage. Of course, the path of the smoke toward these outlets must not be obstructed in any way. It should be possible to open these outlets from the stage and also from at least one other point, easily accessible and protected from smoke and flame. There should be regular drills in the manipulation of the opening apparatus. Automatic opening by pressure of combustion gases, combustion fastenings or connection with the iron curtain is not advisable. The opening of the outlets necessarily fans the flames and the proper moment to effect it should be left to the discretion of the firemen on the stage.

3. A sprinkling apparatus over the stage is useful in some cases. It should not be automatic, but should also be controlled by the firemen.

4. Gas lights are almost sure to be extinguished in a conflagration, and candles and kerosene lamps are unreliable. The safety illumination is best furnished by powerful incandescent electric lights, independent of the general lighting system and supplied by individual accumulators. All exits of auditorium and stage should be marked by *red* lights of this character.

5. Generally speaking, the character of the ordinary

* Abstract of a paper read before the Hamburg Society of Architects and Engineers, December 15, 1905, by Fire Commissioner Westphalen.

* Not more so, however, than the fire in the Iroquois Theater in Chicago.—Trans.

ventilating system has no influence on the safety of the audience in conflagrations.

6. Ample outlets in the roof of the auditorium may be of benefit after the iron curtain has been lowered, but even then their efficiency is diminished by the opening of the doors of the auditorium. On the other hand, such outlets may greatly increase the danger if the iron curtain is not promptly lowered.

7. The corridors and lobbies of both stage and auditorium are important factors of safety. Many old theaters have stage doors communicating directly with the open air. Such doors are highly dangerous and if they are indispensable for the introduction of scenery they should at least be closed during the performance and so fastened that they cannot be opened.

TREATMENT OF RIVERS WITH SHIFTING CHANNELS.

THERE is a portion of the Loire, situated between the towns of Orléans and Nantes, which is included in this particular type of streams. In order to render this stretch of waterway suitable for the purposes of navigation, the French government deputed M. Cuënot, the engineer-in-chief of the Ponts et Chaussées, to undertake a series of experiments and investigations with that object in view. The conclusions arrived at are worthy of record, as they have a very important bearing upon this branch of hydraulic engineering, and from the practical success already achieved, afford good promise of future application upon a more extensive and accentuated scale. There are two distinct methods of treatment recognized under the respective titles of the German and the French methods. The former procedure is based upon the narrowing of the river bed and imparting a uniform sectional area to the stream, and concerns itself only with the conditions obtaining during the period of mean water. The adherents of this system delimitate the future and improved channel upon the lines followed by the current at the time the river is at this level or datum point. This channel will tend to become modified and smoother in its course, since, in accordance with the gradual rise of the water, the lines of flow of the liquid tend to assume positions parallel to the banks. All curves will be of large radius, and will succeed one another in a regular and harmonious manner. The works to be constructed, whether consisting of transverse rows of river weeds, or of longitudinal dykes, will be sufficient to guide the water at its mean level, and the cross section will be a constant quantity, and symmetrical about the axis of the new channel. This method, which consists in virtually converting the bed of the river into a canal of uniform depth, or, in other words, of canalizing the stream, has been successfully put into practical execution in Germany.

It is upon the Rhône that, among other engineers, M. Girardon has employed the French system of dealing with rivers with shifting beds. According to this method, no attempt is made to construct an artificial canal having a uniform depth throughout its entire length, but a lesser or subsidiary channel is marked out, completely independent of the other due to natural formation, and in the form of a sinuous curve. Also, no special constant type of section is adopted, but one is chosen which may be varied at different points, and on both sides of the axis of the channel. At the apex of the curvature the difference is at its greatest, the rise being a maximum on the concave, and a minimum on the convex side, and at the points of inflection the symmetry will be complete. The junction of the sections is effected by a series of gradations. In following the course of a bank of the river, there is thus a succession of works, of which the elevation diminishes at the crown of the curve as far as the convexity, which is on the down-stream part of the river. Upon the opposite bank the face works are arranged in the inverse order. All the reaches are retained in their natural location, and the longitudinal section of the river carefully maintained, so that at low water the slope is steeper over the small dams or sills than over the dips. At high water these conditions are reversed. These differences are introduced for the purpose of keeping a record of the variations which take place in the wetted sections, accordingly as they are regarded during the period of low or high water. Attention is paid to the natural features of the district, by the establishment in the same reach of cross section based upon the data obtained from the information furnished by the soundings. Each reach in this manner retains its original characteristics, so far as they are not antagonistic to the works necessary to the training and regulating of the river. In the construction of these works the elevation is less than that required in the German method, since it is a simple matter to form the framework of the directing banks during the period of low water, while high water tends to preserve the channel of low water in its original position.

The regulating works consist chiefly of transverse rows of river or silt weed rooted in the bank, from which they plunge directly into the stream, extending to the bed of the river, with an inclination from the up to the down-stream side. Ranging always in the same direction, so as to concentrate the water along the axis of the channel, they fulfill their function bit by bit, without affecting the river too abruptly. When required, they are raised, lengthened, and increased in number, accordingly as the stream performs its own duty efficiently. The effect of these silt weeds can be enhanced at the summits of curvature by the aid of longitudinal dykes, which attract and retain the current, and by completely immersing the weeds, so as to diminish the scouring action, and the better to divide the depths throughout the extent of the same cross section. A double result attends the action of these training operations. They narrow and define the river bed, and so affect the longitudinal profile of the stream as to cause the regulation of the slopes between two consecutive sills. The deposits and the transport of other forms of matter are due to the disproportion existing between the immersed sections over the sills and the dips during the time of low and high water, and this disproportion gives rise to the inversion of the slopes. It is reduced by acting upon the longitudinal profile of the river in the following manner: The strength of the current is diminished—or, in other words, the amount of elevation presented by the bed of the river is reduced. No change is made in the total length of the slope, but it is distributed more uniformly along the whole passage, which is consequently considerably improved. The original section of the channel, which was represented by a sinusoidal curvature, becomes flattened, and the length of the wave is a constant quantity, but with a decreasing amplitude.

It may be here mentioned that the employment of silt weeds is very similar to a temporary contrivance which has been very successfully used in the Indian rivers for the purpose of silting up channels in their training and regulation by retarding the current. This object is achieved by the use of grass ropes about 8 inches in diameter, to which brushwood, or any other suitable kind of rough bushes, is fastened. These are moored in the positions selected by grass nets packed with stones and weighing three-quarters of a ton, and buoyed up by empty casks fixed to the upper end. In these cases the length of the cable is equal to about twice the maximum depth of water in the bed of the river to be raised, and the number of ropes employed and the length of the intervals between them is decided, as in every other instance, by the local features and normal conditions of the channel.

One of the troubles attending the exclusive application of the German method of treatment, which had been observed on the Rhône previously to the actual execution of the works since carried out, is the bringing about of a lowering of the water level and the exposure of the shallows on the up-stream reaches. The mode adopted ultimately in dealing with the Rhône, which determines the longitudinal section of the stream, remedies this inconvenience.

Before commencing operations upon the Loire, M. Cuënot satisfied himself that the general condition of the river was similar to that of others of the same character. After examining the record of soundings taken at different periods for eight years he was able to recognize all the features belonging to this class of waterway. They include the division of the rivers into reaches, and the inversion of the slopes at the sills and the deeps, according to the period of high and low water. The problem to be solved was to transmute a passage formed by two successive dips and a sill, and thus convert a bad situation into a good one. Good passages are distinguished by the accompanying characteristics. The dips are broad and placed at a sufficient distance from the concave bank, from which they detach themselves progressively. They are separated by a sill, transverse to the river, forming a short dam over which flows a sheet of dull water with a feeble current. On the other hand, the bad specimens, which are usually due to the rugged alignment of the banks, present a pair of dips riding one over the other, narrow and deep, hugging the concave banks, separated by a diagonal sill running obliquely across the stream, and submerged in a thin stream of water with a rapid current nearly square to the river. The transformation to be accomplished is of great importance, since all the difficulties are united, comprising want of water, abrupt change of direction, and a rapid, violent current. These difficulties have been overcome on the Rhône, where bad passages arising from local and exceptional circumstances no longer exist. The method employed to effect this change has, in this instance, received a practical illustration which is a true test of its merit.

It appears that upon the Loire the situation is not so favorable as upon other rivers, and the object to be attained is rendered the more difficult on account of the disproportion between the flow at low water, which is about 130 cubic yards compared with 7,800 cubic yards at high water. Further, when a series of shallows with dips extend from one bank to the other, the former are distributed very obliquely with respect to the axes of the channel, the inclination varying from 10 to 40 deg., but more generally ranging from 20 to 25 deg. In addition the reaches are very short. From the estuary of the Maine to the town of Nantes the number is 128, which, spread over a total length of 52 miles, gives a mean length of 700 yards. The dips are narrow and deep, ranged alongside the banks in the sharp angles between them and the sills, without any existing relation between their formation or position, and the concavities or convexities of the steep banks. Many defective elements, inherent to the navigation of rivers of the class under review, are in this example strongly in evidence. The shallows are very oblique, giving rise to long dams or weirs with very scanty overflow, the dips override each other, the curvature of the channel is sharpened, and, in order to pass from bank to bank, it is frequently necessary to choose a course at right angles to the longitudinal axes of the channel. Such are bad passages. It is, however, possible to change their character by the adoption of a plan which utilizes as much as possible the natural sinuosities and local features, and by a systematic regulation of the longitudinal section, which diminishes the great disproportion existing between the different sections of the stream.

This method has been attended with considerable success on the Rhône, and also between the mouth of the Maine and Chalonnes. These favorable results have led to the resolution to extend the system to the whole of that part of the river between the embouchure of the Maine and Nantes. This scheme is a sequel, upon a far more extensive scale, to the happy termination of a smaller undertaking, carried out for a distance of nine miles along the waterway between the two towns already mentioned, which are 50 miles apart.—The Engineer.

THE COLLECTING AND TESTING OF CARBONIC ACID FOR PURPOSES OF CARBONIZATION.*

THE carbonic acid generated during the fermentation process in distilleries and breweries has heretofore been generally permitted to escape into the air. It represents, however, a very considerable portion—almost half—of the decomposed sugar, so that its collecting and liquefying, by means of the proper apparatus, can easily be made a profitable undertaking.

According to Pasteur, the chemical formula for the alcoholic fermentation is as follows: 100 grains cane sugar yield 51.1 grains alcohol, 49.2 grains carbonic acid, 3.4 grains glycerin, 0.65 grain succinic acid, and 1.3 grains cellulose, protein, etc. The weight of the carbonic acid developed amounts therefore to about one-half of the total quantity of sugar involved, and when collected, it can be utilized in many ways, especially in the industries which produce the different beverages, for instance, the carbonization of beer, wine, cider, artificial mineral water, etc. If we take into consideration the fact that the natural or spontaneous carbonization of bottled beer, champagne, cider, and other carbonaceous drinks is the result of a slow after-fermentation, it will be easily understood that an initial charge of carbonic acid, produced by a pure alcoholic fermentation and free from all bad odors, etc., is really a close imitation and expedition of the natural process.

By means of a newly patented process the carbonic acid can be produced in an almost chemically pure state and in liquid form, that is, it contains up to 99.9 per cent carbonic acid, the remainder consisting in minute amounts of moisture, alcohol, and air.

A simple method frequently employed in obtaining liquid carbonic acid for the purpose of manufacturing artificial mineral waters and lemonades, is as follows: Bicarbonate of soda or chalk is mixed with sulphuric acid, and the gas generated is compressed at ordinary temperature in the well-known steel cylinders, which are tested to a pressure of 150 atmospheres. The pressure to which a cylinder is exposed when completely filled with condensed gas, at a temperature of 30.9 deg. C. (the critical pressure of carbonic acid), amounts to 77 atmospheres, or half of the cylinder's power of resistance.

This method of producing liquid carbonic acid is, however, nowadays almost discarded, as the handling of concentrated sulphuric acid is not without risk; besides, the carbonic acid thus produced often contains traces of sulphuric acid, and the residue was inconvenient to dispose of. The compressed and liquid carbonic, which is put on the market in the steel cylinders referred to above, and of 10 kilogramme capacity, is generally obtained by either one of the following three processes: 1. It may be the product of natural carbonic acid springs, which occur in regions of volcanic character, for instance, at Burgbrohl on the Rhine, in Germany, where the gas issues from the interior of the earth in considerable quantities and is collected and compressed. Before the gas can be collected it has to be dried, because, on its way through the different strata of the earth, it becomes saturated with moisture.

2. Compressed and liquid carbonic acid can be obtained by the combustion of coke. As it is impossible to control the process of oxidation so as to permit of the formation of carbonic acid alone, the product thus obtained invariably contains carbonic oxide gas, which is injurious to the human organisms, even in the smallest quantities. It is therefore better suited for technical uses, for instance, in refrigerating machines, automobiles, and fire extinguishing apparatus.

3. Carbonic acid of excellent quality, of a high degree of purity and free from odors, etc., is produced during the fermentation process, especially when only grain and malt are used in the production of the wort. If sugar beets or molasses are used in distilleries, the very strong odor from the impurities always present in these raw materials is liable to cling to the carbonic acid and affect its taste and odor.

The carbonic acid developed in the fermentation process in breweries or distilleries not equipped with closed fermenting tubs, can be collected, purified, etc., according to the latest patented process, as follows:

As soon as fermentation sets in, the fermenting vat is covered with a leather hood, which is fastened hermetically tight with cords and iron hooks. Inserted into and tightly connected with the leather hood is a pipe, which takes up the carbonic acid, with the aid of an aspirator, and conveys it to a series of ten filters, each of which is divided into four chambers or compartments. All of the filters are made of strong cast iron. The first of them is empty, and in it the principal part of the moisture settles. The second filter contains a mixture of water, potassium permanganate, sulphate of iron and concentrated sulphuric acid, the proportions being: 2 kilogrammes potassium permanganate, 2 kilogrammes iron sulphate, 2 liters concentrated sulphuric acid, and 60 liters water. The third filter contains 1 kilogramme of paraffin oil; the

* Pure Food Products.

fourth and fifth each 10 liters concentrated sulphuric acid; in the sixth there are 3 liters of the same mixture as in filter No. 2. The seventh filter is charged with 1½ liters of the same mixture, while Nos. 9 and 10 are empty. The carbonic acid thus purified then passes into a drying tower charged with 400 kilogrammes of chloride of lime. The gas is now sufficiently purified and is pumped into the compressor, in which it is subjected to a pressure of 60 to 65 kilogrammes, and thence into a second compressor, from which it is pressed into a refrigerating cylinder. From this receptacle it is filled into the well-known steel cylinders, which have a capacity of about 10 kilogrammes.

Carbonic acid of any origin, if not sufficiently purified, may contain solid, liquid, or gaseous carbonic acid, which may eventually prove injurious. Concerning the estimation and testing of liquid carbonic acid, Bode says in Wochenschrift für Brauerei, 1905, page 369:

"Among the liquid impurities occurring in carbonic acid, are water and fatty oils. Water is objectionable because it is liable to freeze and clog the narrow pipe lines. The presence of water can be detected by means of copper sulphate. Filter paper is impregnated with a saturated solution of sulphate of copper, and dried in a desiccator. It then appears either colorless or has a faintly greenish tint. When held into the mouth of an open carbonic acid cylinder, it quickly turns blue, if there is an abundance of water in the gas. The presence of fat can hardly be entirely avoided in the manufacture of carbonic acid; yet it becomes very obnoxious on account of its tendency to destroy the foam on the beer, so that the brewer cannot be too careful, especially when he begins to receive complaints about the poor foam-keeping quality of his beer."

To determine the presence of fat, Bode recommends the passing of a current of the gas into a reagent glass filled with pure distilled water. All the fat has to be thoroughly removed from the glass by washing in sodium carbonate and afterward rinsing in pure distilled water. After the carbonic acid has been allowed to pass into the water for a time, 1 cubic centimeter ether is poured into the fluid, the glass is closed with a clean, well-fitting ground glass stopper, shaken, and the liquid is allowed to settle. A strip of glue-coated paper is then dipped into the ether, and if fat is present, a characteristic stain will remain on the paper after the evaporation of the ether.

Of gaseous impurities, carbonic acid may contain air, carbonic oxide, sulphureted hydrogen, and carbohydrates. The air in carbonic acid impairs the foam keeping quality of the beer. Carbonic oxide is injurious to the human organism. Both these gases are detected in the following way: A tube divided into 0.5 cubic centimeter degrees is filled with warm water, closed with the thumb and held upside down in a basin containing warm water. The thumb is removed and the tube filled with carbonic acid to the 100 mark, closed again, and placed into a vessel containing diluted potash or soda lye. The alkaline solution absorbs all the carbonic acid, while any unabsorbed gas remaining in the tube represents impurities. Their volume can be read off when the measuring tube is placed for a time on the water-bath of the same degree of temperature at which it had been filled with carbonic acid, care being taken to keep the water at the same level inside and outside of the tube. The number of cubic centimeters read off indicates the percentage of foreign gases (air, carbonic oxide, carbureted hydrogen, and carbonic acid).

The presence of sulphureted hydrogen is seen by the turning brown or black of a strip of paper that had been saturated in lead acetate and is held up to the mouth of the open carbonic acid flask.

Where the tests just described cannot be made, it is best to pass the carbonic acid into pure water and try its taste. The water must remain odorless and free from any strange by-taste.

As already mentioned the carbonic acid obtained from the fermenting tub is generally very pure and the carbonic acid that is purified according to the method described, will be found, if all the apparatus are carefully and intelligently used, to be perfectly free from all impurities, excepting only some traces of air.—Dr. H. Stiegeler.

GREENHOUSE AND CONSERVATORY HEATING.*

By A. S. ATKINSON.

THE proper heating of a modern greenhouse or conservatory is a problem involving a number of special features quite different from those which pertain to almost any other type of structure. A uniform and constant temperature is absolutely essential to success, and any plant which fails to furnish this must in the end cause a good deal of loss and anxiety to the owner. The possessor of a modern greenhouse frequently carries commercial stock through the winter valued at hundreds, if not thousands of dollars, and a single day or night in midwinter without proper heat would mean a large if not total loss. Near Philadelphia there is a single greenhouse holding a collection of tender orchids, the total value of which is estimated at $50,000.

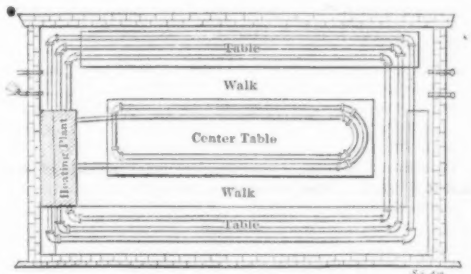
Reliability of any heating plant for a greenhouse is thus one of the most important considerations. In the past the heating plants of greenhouses have too often been chiefly a matter of makeshift, and trouble has been a constant factor in the situation. A good deal of this has been due to the desire on the part of the owner to install a heating plant as cheaply as possible. In some cases second-hand furnaces, steam and hot water pipes have been purchased and assembled on the site by amateurs. Not being a perfect unit, the plant has discouraged many owners from undertaking the work the second time.

Only the past half dozen years, it may be said, has the greenhouse heating system received the attention it deserves. The growing popularity of the conservatory and commercial greenhouse has demanded more study of the conditions which assure success. The construction and designing of the buildings have reached a stage where comparatively excellent results can be obtained. Architects and builders have determined the best size, shape, situation and kind of material suitable for either the conservatory of the amateur or the greenhouse for commercial purposes.

But the tightest and warmest greenhouse without an appropriate heating plant may prove worthless. It will in the end develop into an expensive and wasteful luxury. Many have gone out of the business through serious trouble in this line.

The proper heating of the greenhouse demands the best services of experts, for in our varying climate conditions are rarely the same in any number of States. Moreover, the nature of the plant collection must be a determining factor. Rare tropical orchids demand a much higher temperature, maintained evenly throughout the winter, than many of our ordinary semi-hardy plants. The rapid changes in our winter climate likewise require proper ventilation and automatic control of the heating plant to prevent the temperature in the house from injuring the plants through excessive heat. Nearly as much damage is done to greenhouse plants from too high a temperature as from too low.

A hot-water plant properly installed and equipped serves the purpose of greenhouse heating better than any other system. The heat from hot-water circulation imparts a mild and congenial warmth to the air, and at the same time it is practically free from impurities. Where coal stoves are used the gas from the burning coal and the impurities from the dust and ashes have a disastrous effect upon the more delicate plants. The excessively dry air of the stove or furnace heat tends to destroy the vitality of the plants, so that, unless constantly watered and sprayed, the



air will suck out the moisture from the leaves and stalks very rapidly. Such an atmosphere is much like the hot, dry winds of the West, which wither up corn and grass within a few short weeks in summer, so that the crops are reduced one-half, or entirely destroyed.

By means of a good hot-water plant a greenhouse upward of 300 feet in length can be properly heated in winter by a single boiler located at one end. The plant is furthermore adapted to the heating of two or three small greenhouses placed either in a group or run along in a series. Owing to the different needs of some plants many florists prefer to divide their greenhouses in small groups or units so that different temperatures can be maintained in each.

In designing the heating apparatus for a greenhouse, estimates are figured generally upon a basis of 55 to 60 deg. to be maintained in the temperature of the house in zero weather. An average temperature of 150 deg. in the pipes is calculated upon to secure this result. Such estimates are modified somewhat by the character of the greenhouse itself, such as shape and dimensions, and whether constructed of brick or wood, single or double boarded, and also the direction in which the greenhouse faces. All of these factors modify the conditions so that the engineer must make his calculations for the size of the boiler required upon exact facts. The nature of the fuel intended for use is another point that must be considered, for where soft coal is to be burned a larger boiler is generally recommended than for hard coal. The proper siding and construction of the greenhouse insures protection from cold outside drafts, so that the heating is much easier arranged.

In small conservatories and amateur greenhouses the ordinary round boiler answers all purposes, and, owing to its cheaper cost, is most popular; but in a large commercial greenhouse sectional steam and water boilers are necessary. A cast-iron sectional boiler properly made and of the right dimensions gives the best results. They are safer, more durable, and more economical for this kind of heating than the wrought iron or steel tubular boilers. If properly designed they can be set independent of brickwork and in such a way as to occupy less space. These considerations have made this type of boiler popular for greenhouse heating.

A boiler for greenhouse should be simple in management and capable of maintaining a steady temperature from eight to ten hours without attention. It should also be economical in operation and cost of repairs, and every part easy of access for cleaning. The florist running a commercial greenhouse cannot employ an engineer to look after his hot water or steam plant, and he is not generally much of an engineer himself. For this reason the plant must be laid out on simple lines and with as few technicalities as possible. The boiler must be largely automatic in its operation.

The layout and dimensions of the mains and radiating pipes should be so as to distribute the heat economically and uniformly. It is fatal to a greenhouse to have one part overheated and another part underheated. A good deal of the result will depend upon the size and direction of the mains so as to keep up an active circulation. For large greenhouses the open tank hot-water apparatus probably gives the best results. In a properly constructed plant the entire control of the heat should be regulated by the draft damper on the boiler after the pipe coils have once been heated. The fire should be increased or decreased by the draft regulator so that the temperature can be made to suit any weather. By means of the chimney draft the temperature of the greenhouse is increased or decreased automatically.

In the open-tank system of hot-water heating for greenhouses the dimensions of the boiler are first made to suit the needs of the house, or of such size as necessary to heat the amount of radiating surface estimated essential for a given space. The boiler is connected at the bottom and top with the flow and return mains, and branches are taken from the mains to the coils of radiating pipes. One of these coils, placed along the side or under bench or table, is generally sufficient to heat a small "lean-to" greenhouse, but for larger houses two or three are needed. When the houses are connected together in a series a single pipe coil will often answer for each one. The coils, consisting of two or more pipes laid conveniently together, are connected at the highest point to a pipe header, and at the lowest point with branches which connect them with the flow and return mains. In the pipe header there should be placed an automatic air valve which will permit the air which accumulates in the pipes to escape.

The expansion tank connected with such a system is located over the boiler above the highest pipe in the system. This tank is connected by a pipe to the return main and also to the water supply. It is equipped with a glass water column and an overflow pipe leading to some outside drainage. The object of this expansion tank is to prevent the waste of water by overflow, and hence to save fuel and hot water. In apparatus of this description water heated say from 40 to 212 deg. will expand about one-twentieth of its volume, and unless an open expansion tank is provided the waste through overflow will be considerable.

A good effective boiler for greenhouse work should have a coal area of about fifty per cent larger than that of the grates, which is essential for maintaining a proper temperature during the cold winter nights. Anything short of this amount of space may cause trouble at critical moments. The firebox should be unusually deep to provide ample space for good combustion of the gases, and the fire channels over the fireboxes to the boilers should incline toward the fire so as to direct the heat directly against the boiler surface. The concentration of the fire in a series of currents thus produces more force than if scattered.

The firebox should properly be connected with the smoke pipe so that no smoking or back-draft can follow. By means of a wide U-shaped flue extending a considerable distance parallel with the boiler a good part of the escaping heat is utilized in heating the water

The grates of the furnace should be of ample size and designed to receive and hold a good bed of coals, and when cleaned be simple of operation. The loosening and discharging of clinkers without any great skill is an important consideration. Without properly designed grates the furnace will never give satisfaction, and all the improvements made in other parts of the plant will be nullified.

The application of the principle of hot water circulation to greenhouse heating is due to its adaptability. In installing such a plant it must be remembered that it is gravity which produces the circulation of the water through the system. It is the difference in the weight between ascending and descending columns of water in the perpendicular flow and return pipes. With water at its greatest density at 39 deg. F., the volume increases, and the density decreases as the boiler heats it. This means that the heated water becomes lighter. As it becomes heated and lighter in the boiler through expansion it is forced through the boiler outlet and flow pipes to the radiating coils by the colder water descending through the return pipes. The water as it makes its journey imparts its heat to the surrounding atmosphere, and grows heavier in weight and density. By the time it reaches the boiler again it is sufficiently cool and heavy to force the lighter water up through the same circulation. To secure the most desirable results with such a system the pipes and mains should be laid out with as few sharp inclines as possible, and the outlet should be of ample size and placed at the highest point of the boiler. This insures free and rapid circulation with the minimum of friction. The economy of operation of such a heating plant depends upon the comparatively free and easy circulation of the hot water through the system, and anything that causes friction means an increase in the coal bills.

* The National Builder.

The coefficient of linear expansion of concrete of the proportions 1 : 2 : 4 has been determined as 0.0000055 for 1 deg. Fah., while for steel it is 0.0000066, and for wrought iron 0.0000068.

PAJARITO RUINS—THEIR ACCESSIBILITY.*

By HUGH H. HARRIS.

SIX months of continual riding, as Forest Ranger in the Jemez Forest Reserve, has enabled me to see only a portion of the vast number of archæological ruins in the Pajarito region. Every new canyon explored, every new mesa opened by the extension of the system of Forest Service Trails, and each out of the way place chanced upon shows its treasures of cavate dwellings, communal house, watch tower or some relic of the cliff dwelling period.

Puyé, Tsankawi, Otowi, Navakwi, Tehirege (or more commonly called Pajarito), and the Frijoles have been brought to the attention of the public more than other regions, but to me there are sections far more interesting than these. Along the same general lines, of course, and possibly smaller in individual extent, there are groups of ruins within an easy day's trip that have apparently rarely if ever been visited by Americans. Here and there some Indian in hope of gain may possibly have done some rude scratching, but in the main these ruins are untouched. On the other hand, the better known ruins show the signs of a good deal of modern research, or in other cases mere vandalism.

Some of these sections show an amazing number of ruins of all types in a remarkably small area.

About two miles southwest of Puyé are cliffs containing numerous cavate dwellings. These dwellings do not seem to be as regular in size as in the average cliff, but vary from the smallest to the largest sizes I have seen. In one of these dwellings I took refuge during a stormy night with my saddle and pack horses, and found that it afforded ample room. It had been fenced in front, in years gone by, and used by sheep herders as a stable for their pack animals. This house is of course of unusual size, the average being either circular or in the shape of a rectangle, generally with a dome roof and 4 to 5 feet across, when rectangular, and only slightly longer in the greatest dimension.

The crests of the cliffs in question are in the form of a narrow mesa. This mesa is broken in three places, practically forming four small mesas. Two of these sub-mesas contain communal houses several hundred rooms in extent each. They are in unusually good condition, and the rough hewn rectangular stones form heaps some 15 feet above the surrounding ground. The shapes of the rooms and of the entire structure can easily be seen. They are even distinct enough to show without excavating that the structures were several stories in height, the lower story containing a much larger number of rooms than the one above it.

To the north of these houses on the first cliff, and easily accessible on horseback or on foot, are two additional large communal houses, while on the slight ridge to the south, to which even any class of vehicles can be driven, are two more houses. This gives a total of six large communal houses, uncounted smaller ones and watch towers, and hundreds of cavate dwellings within a very easy day's trip.

Another interesting feature of these dwellings is that they all seem in about the same state of repair, and not as at Otowi, and some of the other points showing a disparity of ages. This apparently indicates that a large part of these ruins, if not all, were inhabited at the same time. If so it is hard to picture even what a busy hive of activity this section must have been.

It is especially fortunate that this group is situated as near Española as it is for those who desire to make a quick trip to the ancient abodes. The Puyé ruins, previously most visited, are on the Indian reservation, and it is necessary to obtain permits to visit them, often necessitating a delay. All ruins in the forest reserve can be visited without permit, although excavating or any form of vandalism is strictly forbidden.

Unusual interest has been taken this year by the citizens of Santa Fe and Española in this region. Recognizing the value from a tourist's standpoint, the business men have started a movement to advertise this great section as well as to put the roads and trails in better condition. In addition to this the Santa Fe Archæological Society has taken on new life, and has added many new names to the membership roll. Its membership embraces now practically all of the prominent people of the city, and a number are very much interested in the work.

CLIFF VILLAGE OF PUYÉ.

Scores of parties have been formed to visit the cliffs, and many tourists have also availed themselves of the opportunity offered to see the region. The number of people who have seen and will see the cliffs before the season is over far exceeds those of any previous year.

The co-operation of the forest service has been asked, and it is probable that a system of forest reserve trails will be made bearing in mind the sightseer and archæologist. The rangers' cabins will also probably be built this winter, and made large enough for the joint use of ranger and tourist.

At present a large portion of the ruins, both in the reserve and in the Vigil grant north of the Frijoles canyon is easily accessible by road or trail. This embodies the main portion of the country occupied by the Tewa tribes in this section.

Rito de los Frijoles ("little river of the beans") and the Keres region south are only reached with difficulty. This region contains the stone lions of Cochiti, the painted cave and other points of interest. It is to this region that efforts are to be directed to make it more accessible.

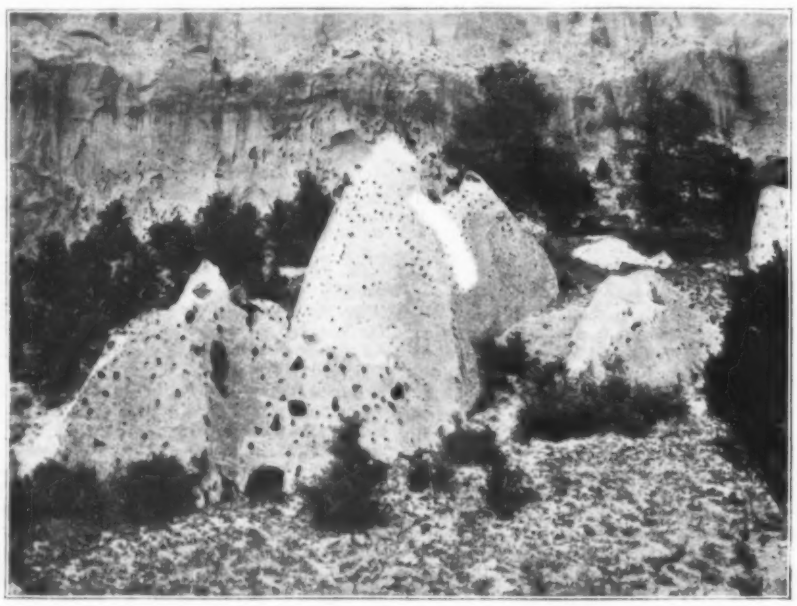
The main entrance up to the present time has been down White Rock Canyon, along the Rio Grande to the mouth of the Frijoles, then over the steep Navajo war trail across the high mesa and then down again into the Frijoles canyon. This trail leads over lava beds and is dangerous and difficult for both the tourist and his animals. A committee from the Santa Fe society went over this trail with Prof. Hewett and decided to put it in better repair for next season.

I have recently been looking over the country above, and have decided that a much easier trail is available across the tops of the mesas. It will be no longer, better time can be made on it, it is not dangerous, and the traveler will pass several other ruins of interest. This will be reported to the society in the near future.

Recognizing the fact that if this region is ever properly advertised to tourists, or known as it should be by archæologists, thousands will visit it annually, there are numerous people who have made themselves familiar with parts of the region, and are ready to act as guides.

One can now secure conveyance at Santa Fe and drive to the ruins, or take the train to Española and go in from there, or still, if preferable, arrange with the Indian guides for horse or burro outfits. Española will enable one to go to the ruins and return in the same day, but few who have any interest in these wonders will be satisfied with such a short stay. A night or so spent around the cheery camp fire, where tales of the ancient race are told, will add much to the pleasure of the trip.

It is a matter of congratulation that the forest service is protecting these rich stores of archæology, and the tourist who makes a western trip without a sight of this interesting region has in my opinion missed one of the best attractions in the West.



TENT-ROCK CLIFF DWELLINGS NEAR OTOWI CANYON.

* Records of the Past.

HERCULANEUM.

THE announcement that the Italian Central Commission of Antiquities and Fine Arts have approved of Prof. Waldstein's project for the excavation of Herculaneum shows a surprising degree of liberality. The whole history of the attempts to reveal the buried city during the last two centuries has been marked by the most remarkable dog-in-the-manger spirit known in the history of archæology. When Naples was a kingdom a fierce jealousy was displayed toward inquirers who came from other parts of Italy, and still more to foreigners. Now that Italy has become united it is felt by those who have the interests of the country at heart that the condition of Herculaneum is discreditable to the people and government of Italy, and that an effort should be made to imitate the action of countries like Turkey and Greece. But the conditions of the acceptance of Prof. Waldstein's proposal are still marked in a large measure by the old spirit. Foreigners will enjoy the privilege of contributing toward the expenses of the excavation, but the money is to be controlled by an international administration under a president to be nominated by the King of Italy, and who doubtless will be an Italian. The execution of the work will be directed by a commission, one-half of whom will be Italian. All the information concerning the discoveries is to come from the Italian government, and Italy is to retain possession of whatever is found. Foreigners will recognize the justice of the last condition, for it corresponds with the practice in other countries. But it is to be feared that the interference of Italians with the excavations will be prejudicial to the success of the enterprise.

It was in 1706, or exactly 200 years ago, that the existence of Herculaneum was revealed. Prince Emanuel of Lorraine, who had settled at Portici, then ordered the erection of a villa. For plaster he proposed to utilize some crushed marble. He was informed that people in the town knew of the existence of a pit or well, and on descending by it they were able to find not only pieces of marble, but statues and mosaics. The Prince wisely secured possession of the well, as well as of rights of search. It was about 90 feet deep, and in passing downward it was not difficult for a trained eye to realize the remains of different towns. The ancient city which was overwhelmed in A. D. 79 was used as a site for other cities which were also destroyed. It was therefore not strange that the city known as Herculaneum was forgotten. The Prince d'Elbœuf, for that was the title by which he was known, carried on explorations for a few years. At such a depth the work resembled mining, with the difference that in mines there are plans to be followed, and the lines of the strata serve as guides. At Hercu-

Museum there could be no plan, and the men burrowed around, regardless of what was destroyed, so long as they obtained a statue, or a part of one, or a mosaic. The French president, De Brosses, who descended in 1739, said that owing to the absence of air he was unable to examine the place without going every few moments to the opening in order to continue breathing. He tells us he could discern walls which were

TYPICAL ENTRANCES, SHOWING PICTOGRAPHS.

examples of *opus reticulatum*, others adorned with mosaics, large slabs of marble, and frescoes representing flowers, birds, animals, and other ornamentation, but even lighter in style than arabesques. He could also see columns, bases, capitals, fragments of statues, and of furniture, pieces of bronze, and in his presence an inscription was discovered which appeared to be a list of municipal magistrates. He recognized that they were in the presence of an amphitheater or of a theater. He was also able to perceive the remains of a street, along which were covered benches. De Brosses was informed that it led to some public building, with porticoes, which contained much fresco painting, columns, and statues of men seated in curule chairs. De Brosses was able to realize how imperfect was the excavation, for in spite of all that had been done during thirty years there did not appear to be any open space exposed, for what was dug out in one spot was cast down in another. If, as he said, so much has been discovered by digging blindly (*en fouillant à l'aveugle*), it was not difficult to imagine what would be produced by methodical research. Then he mentions the statues of divinities and emperors which had been obtained, and he particularly remarked statues of the entire family of Nonius Balbus, which were found in one place, a family of great interest in the history of ancient art, for some of the masterpieces which were prized in Rome once belonged to them.

The discovery of the statues of the Nonia family had an unexpected effect. The Austrian Viceroy considered his master was being deprived of treasures. He therefore not only put a stop to the exploration, but demanded of the Prince d'Elbœuf all the works of art he had taken from the subterranean city. A few years afterward Naples obtained a new monarch. He decided to erect a palace at Portici, and ancient Herculaneum was relied on to furnish the means of its adornment. Col. Alcubierre, an officer of engineers, was appointed architect. He treated the remains with as little mercy as if they were obstacles in a campaign and his subordinates were pioneers. He succeeded, however, in revealing a theater which at first was thought to be a temple. The news of the discovery was heard with surprise throughout Europe, and many archæologists traveled to Naples in order to see the new wonders. But the officials of the Neapolitan government looked on the discoveries as if they were monopolies from which profit in some form or another was sure to be derived; and in consequence the advice of experts which might have been obtained gratuitously was withheld. Any further work attempted was continued in the old unsystematic manner.

The spirit which animated the Neapolitans, and which remains unchanged, can be judged from their conduct to Winckelmann. He was a German, but he had become an abbé, and was an official of the Roman Court. He was recognized as the foremost authority on ancient art. He went to Naples and obtained permission to visit Herculaneum, but he was never allowed to go about without some agents. He made a second visit a few years afterward, and wrote a book on the antiquities. His intentions could by an impartial critic be understood from the pages, yet when he went again to the ruins he was not accorded uninterrupted liberty in walking, for fear he was measuring the old city, and care was taken to conceal the latest discoveries from him. The King of Naples had, in fact, given orders that an official description of Herculaneum was to be published. The commission was given to Beyardi. But as the introduction, which treated mainly of mythology, occupied about five volumes, the order was given to Bernardo Tenucci, one of the royal secretaries, and forty years elapsed before the completion of the work.

The discovery of Pompeii in 1748 and the comparative ease with which the buildings were cleared could not fail to have an effect on the excavations at Herculaneum. For about forty years they were continued with occasional intervals. But as only a few excavators could be employed the progress was slow. In 1828 the exploration was resumed, and continued for about ten years. In 1866 another effort was made, but the results were unsatisfactory, and for several years it was believed either that Herculaneum was exhausted as a treasury of ancient art, or that the risks to the people living in the modern town were too great to be accepted. It requires therefore a large amount of courage in those who will accept responsibility for the proposed operations, and the whole civilized world must follow their efforts with unceasing interest. Herculaneum is to archæologists what the North Pole is to seamen. Difficult as the task is found to be in both cases, it cannot be said to be impossible.—The Architect and Contract Reporter.

MARS AS A PLACE TO INHABIT.

THE New York Sun in one of its recent issues published a letter in which the habitability of Mars is presented in a new light. Although the writer of the letter has not taken into account the fact that the "canals" have been photographed by Mr. Lampland nor the peculiar artificial relation of "canals" to "oases," his theories are so new and interesting that we publish them herewith.

What can we know or confidently presume or reasonably guess as to the present existence of intelligent beings upon Mars? asks this unknown writer.

It is natural to us to believe that this one little globe is not the sole theater of reason in the vast multitude of the heavenly bodies; and what it is natural for us to believe about any practical matter, concerning which error might imperil the continuance of our race, can hardly fail to be, at least vaguely, true. Mind seems to us to be utterly unlike anything else; and if it really be so its appearance anywhere would seem to argue a tendency in it to spring up everywhere, though that there are some prerequisite conditions to be satisfied is evident from the fact that it is not everywhere actually found. It may possibly be that among the countless orbs in space there is some other than this earth where there live white men just like ourselves and speaking the English language. But it does not seem likely, because the conditions requisite for the formation of our language have been so very special. Now, it may be that what we think of as intelligence is almost equally special; so that just as the Greeks regarded those who did not speak Greek—the so-called barbarians—as hardly rational, we make a great mistake in thinking that what we call "intelligence" is the highest form of being. So it may be; but there are philosophical reasons for thinking that it is not so, and that reason really is something peculiar, unlike anything else, and therefore, since it is found somewhere, would be found everywhere where suitable conditions of a very broad kind were fulfilled; and the chances are as billions to one that such conditions are in fact fulfilled on many celestial masses.

But as to the planet Mars, the most minutely observable body outside the orbit of the moon and at the same time of all known to us the one on which conditions are most like those on the earth, is it not possible that we may reach more definite conclusions? If so, we must reason by analogy; and therefore the very first step upon which every competent reasoner must and will insist as precedent to all others will be to examine the respects in which the analogy between Mars and the earth fails. By far the most important of these respects is the smaller size of Mars. Its dimensions are only 0.53 those of the earth. Naturally, therefore, the material is less compressed, the mean density being only 71 per cent of that of the earth. The consequence is that gravity on the surface of Mars is only 71 per cent of 0.53, or three-eighths of gravity on the surface of the earth. The pint of water that on the earth weighs a pound would on a spring balance weigh but six ounces on Mars. In all terrestrial things the momentum of a body at any given velocity is strictly proportional to its weight. We have no familiar experience with any different state of things. Yet any moving body, say a flood of water, on the surface of Mars has the same momentum as it would have upon the earth, while it presses down on the ground with only three-eighths of its terrestrial weight, and is therefore retarded by friction by as much less. Hence anything which is projected with any force along the surface of the planet Mars must move much farther, other things being equal, and along a much straighter path, and this will in particular be true of any streams of water.

Another consequence of the same facts is that the mass of Mars is only 71 per cent of the cube of 0.53, or about one-tenth of the earth's mass; so that the force of gravity at any distance from the center of Mars will be only one-tenth of the gravity toward the center of the earth at the same distance. Or, since gravitation varies inversely as the square of the distance, in order that a body should be attracted to Mars as much as an equal body is attracted to the earth the distance of the former from the center of Mars must not exceed $7/\sqrt{10}$ of the distance of the latter from the center of the earth. Consequently, were the temperature the same the upper limit of any given gaseous constituent of the atmosphere would be only one-third as high above the center of Mars as it is above the center of the earth. Now, since the very surface of Mars is much higher than one-third the height of the top of the earth's atmosphere, if Mars has any oxygen atmosphere at all it must owe this to the fact that the temperature of the upper atmosphere is lower than about the earth. Possibly, for example, the oxygen is there solid. We may suppose that Mars originally had relatively as much atmosphere as the earth had. If so, it

A SELECT DWELLING WITH ROOMS CONNECTED.

has lost the bulk of it through the weakness of its attractive force; and it probably now retains excessively little except what is composed of substances partly congenied and so without expansive energy. In view of this slight atmosphere, very little erosion of any of the kinds that are familiar to us on the earth can be active on Mars. Erosion of a different kind there must, however, be; for the direct radiation of the sun on the surface of Mars must have a heating effect fully quadruple its effect on the solid surface of the earth; since, if we remember rightly, the late lamented Langley showed that nine-tenths of the sun's heat is cut off in the upper air (we may have the precise value wrong) Mars is half as far again from the sun as the earth is, and so receives on a given area only four-ninths as much heat. This refers to the top of the atmosphere. That of Mars absorbs hardly at all, that of the earth at least eight out of every nine parts; hence at the solid surface the sun's radiation has four times the power on Mars that it has on the earth.

In the spring of the Martian year (of 688 days) lofty ice caps cover its pole, and probably there are other places where ice has collected on mountain tops. Under the blaze of the sun, instead of glaciers breaking off icebergs from their bases as on our own planet, avalanches of ice must come thundering down from the summits. If they did not find channels ready cut for them by myriads of former such masses they would begin themselves to cut such channels. But they must find them cut, and once cut, owing to there being so very little air, the surfaces of these channels must remain smooth and perfect. The almost frictionless ice, with a specific gravity only one-third that which water has here, must slide along this channel, rapidly melting as it goes, and carrying vegetative life beyond the equator. At the same time, owing to the absence of ordinary erosion and to the small gravitative attraction, the ice masses must at certain points be liable to strike rocks which sharply deflect those that happen to strike them, and thus furcations must occur in these channels.

So much for what, as it would seem, must happen. Now, what is actually observed? In the first place no kind of observation is so excessively difficult as the observation of the face of a planet. Not owing to defective instruments, but to the lack of sufficiently fine observers, it was not until 1877 that anybody saw anything that seemed to indicate the presence of a channel on Mars. Mr. Percival Lowell above all and a number of others have now been able to discern not the waterways themselves, but dark bands apparently of vegetation along the borders of unseen channels. These bands appear in the Martian spring, and reappear yearly in the same places. To Mr. Lowell, unquestionably the best observer of them, they have looked decidedly artificial, owing to their extraordinary straightness, to the smoothness and uniformity of each one, and to their radiating from special points. But the first two of these characters must be in part illusions, due to well-known and ineluctable laws of psychology. Beyond that the straightness must be largely due to the small gravitation on Mars as above explained. Since we do not see the channels themselves, but only the vegetation stimulated by the streams, and since vegetable growth is a natural process, one does not easily see how the apparent uniformity of the dimly-made outmarking can be any evidence of artificiality. If they radiate from special points we may naturally suppose that there are mountains or places where for some reason ice is piled up in winter, unless, indeed, there be evidence of design in the location of these centers. The appearance of artificiality will strike everybody; but it will convince different people according to the quality of self-criticism which they apply to their reasoning. There is another feature of the channels that suggests artificiality, yet to which I have seen no other allusion than three words in Biologist Morse's book, "Mars and Its Mystery," page 142, where he speaks of their "angles of approach." They certainly seem to cross one another at angles such as one does not expect to see in natural streams. This may, however, be partly illusion and partly the effect of the ice masses of little weight but great momentum striking on certain faces of rock.

If these channels are artificial, how shall we eventually be convinced that they are so? What phenomenon will point unequivocally to their artificial origin? The intelligent race, if there be one, must either be multiplying or, more likely, dying out. In the former case we ought to be able to detect some subservience to a purpose or to a convenience in the location of the oases, or vegetative spots; and the canals should multiply as the years go by. If, on the other hand, the race is dying out, the oases and the channels should, some of them, fall into desuetude; and those that remain should naturally form a clustered collection. Nothing of all this has, however, yet been noticed.

It may be that there is intelligence on Mars without its having produced any effects that man can as yet observe. It may be that there has been intelligent life on Mars, but that it is now forever extinct, as that on this earth is going to be, perhaps before another millennium has flitted by. It may be there never was and never will be an animal on that planet guided by anything but irreflective instinct. Is not reason, by the way, for the most part a rather futile makeshift? Mightn't a good sound instinct answer the purpose better?

In any manufacturing enterprise a standing committee on which both employees and management are represented which meets at stated intervals is an excellent method of "getting together" those who are competent to act, that each may see the other side of the shield and obtain the other's point of view. There are frequent occasions arising when the management is anxious to know what attitude the employees would take in case a change in policy is made. On the other hand, the employees from time to time wish to lay a request before the management. In either case some temporary device is usually resorted to to meet the occasion. When a standing committee exists, however, a channel of communication is always open and each side keeps thoroughly in touch with the other on all matters of common interest. An honor system is thereby established among the employees and the discipline improves greatly. Generally the rank and file of the working organization is considered in the same category as the privates in an army—they are not supposed to think, but to do as someone above them has planned. The usual result, as might be expected, is that they do not use their brains for the benefit of the concern.

GAS AS A SOURCE OF POWER.—I.*

GENERATION OF PRODUCER, MOND, AND BLAST FURNACE GASES.

By WILLARD L. CASE.

THIS paper claims little originality in itself; it is an arrangement of facts and data obtained from various authoritative sources; quotations are freely made from valuable papers read at one time or another before the technical societies, especially from the very practical papers of Mr. Alexander M. Gow and Mr. J. R. Ribbins.

The gas engine has proved its worth and demonstrated its ability to work successfully on all our commercial gases, producing a conversion efficiency greatly in excess of that obtained by any other heat motor.

The problem of a fuel gas supply, of proper quantity and quality to serve a modern power plant, has worked itself out and down to the very basis you have outlined:

"Blast Furnace and Coke Oven Gases"—by-products of extensive industries—for those power plants in localities adjacent to or which can be served from these works; "Producer Gases"—of which "Mond Gas" is one—for the average or general power plant installation.

The future progress of the gas engine depends upon all these three gases; but more particularly upon producer gas—a gas manufactured especially for power and possible of generation and use in any locality.

If we set forth, even in a general way, the specifications for an ideal power gas and note the general characteristics of the various commercial gases in comparison therewith, we have evidence as to why this problem has so determined itself: Very briefly, we want a gas uniform in quality and clean, containing a low percentage of hydrogen and inert gases; a gas capable of production in a plant of the least complexity of apparatus and of the greatest simplicity in operation, and capable of production from the most readily available fuels and at the least possible cost.

To secure a gas of the greatest possible uniformity in composition, it is necessary that it be generated by that process which, more nearly than any other, maintains constant all conditions affecting its generation; for this reason the process, in operation, should approach the continuous rather than the intermittent; the latter involves periodical alterations of generating conditions. Clean gas is an essential requisite, and therefore the gasification of the fuel should be wholly completed within the generator, and the gas leave the generator free from all those impurities that cause trouble in the engine by scouring or fouling valves and cylinders; no cleaning apparatus, other than a simple scrubber for the purpose of removing fine dust held in suspension, should be required.

For the composition of the gases we would have as low a percentage of inert gases and of free hydrogen as possible—the reasons for which are evident—the richer the gas, the less volume there is to be handled and stored; the lower the percentage of hydrogen the less will be the flame temperature of the mixture and the slower the combustion, which permits of higher degrees of compression and a consequent greater efficiency in the engine cylinder.

In order to produce a gas at the lowest possible cost, the gas plant must have the least complexity of apparatus and operation; there must be the fewest possible number of distinct operations and auxiliaries; for, while there are several by-product recovery systems which lessen the cost of gas production by the recovery and sale of such products, it is not advisable, nor is it desirable, for the average power plant to engage in operations entirely distinct from its own special field of work. Furthermore, the gas process itself must give a high conversion efficiency and must furnish a product under these conditions from the cheapest grades of fuel.

Before outlining the characteristics of the various commercial gases it may be advisable to first note some very general conditions.

All fuel may be converted into gas; but whether the gases of such a conversion are combustible or not depends upon the nature of the materials used and the methods of their gasification.

The complete combustion of fuels produces incombustible waste gases containing carbonic acid and water, with nitrogen and possibly some oxygen of the air supply; their incomplete combustion produces, in addition, combustible products containing hydrogen, carbon monoxide, hydrocarbons and possibly tar and smoke as products of distillation.

In the first process four operations take place—the fuel elements are vaporized, distilled, gasified, and burned; in the second, the fuel is vaporized, distilled, and gasified—and this is the process of making fuel gas.

The commercial gases are designated according to the methods employed in their manufacture or the raw materials used. They are: natural gas, retort gas, water gas, oil gas, carbureted water gas, producer gas, coke oven gas and blast furnace gas. These gases differ from each other in the proportion of their constituent gases, which are oxygen, hydrogen, carbon dioxide, carbon monoxide, methane, ethylene, nitrogen, and sulphur in small quantities. The value of these constituents may be briefly noted: Oxygen is not to be considered as having any heating value; to the extent it appears just that much less oxygen will have to be supplied from air to burn the gas.

Hydrogen appears either as free hydrogen or combined with carbon as hydrocarbon. It has a calorific value of 320 B. T. U. per cubic foot.

Carbon dioxide has no power to produce heat; it is an inert gas acting only as a diluent and reducing the calorific value of the mixture.

Carbon monoxide has the same calorific value as hydrogen—320 B. T. U. per cubic foot.

Methane has a calorific value of 1,000 B. T. U. per cubic foot. It is a slow burning gas, and for this reason a particularly desirable constituent of a gas for engine use.

Ethylene, often given as "Illuminants" in analysis, has a calorific value of 1,600 B. T. U., but appears to only a small extent in the commercial gases.

The illuminants or heavier hydrocarbons form a very small percentage of commercial power gases.

Nitrogen and sulphur have no heat value and act as a diluent to the mixture retarding its combustion and reducing its calorific value.

A typical analysis of the commercial gases, which sets forth their general characteristics follows:

	Natural Gas.	Retort Gas.	Water Gas.	Oil Gas.	Carburetted Water Gas.	Producer Gas from			Coke Oven Gas.	Blast Furnace Gas.
						Anthracite.	Bituminous	Coke.		
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Hydrogen	3·0	46·0	48·0	32·0	40·0	20·0	10·0	10·0	50·0	1·0
Methane	92·0	40·0	2·0	48·0	25·0	—	3·0	—	36·0	—
Ethylene	3·0	5·0	—	16·5	8·5	—	0·5	—	4·0	—
Carbon monoxide	—	0·0	38·0	—	19·0	25·0	23·0	29·0	6·0	27·5
Carbon dioxide	—	0·5	6·0	—	3·0	5·0	4·5	1·5	11·5	
Nitrogen	2·0	2·0	5·5	3·0	4·0	49·5	58·0	56·0	2·0	60·0
Oxygen	—	0·5	0·5	0·5	0·5	0·5	0·5	0·5	0·5	—

Natural gas has a calorific value of about 1,000 B. T. U. It requires 9.73 cubic feet of air per cubic foot of gas for combustion, the resultant mixture having a value of 91 B. T. U. per cubic foot.

Retort, or coal gas, as it was formerly called, has a calorific value of 668 B. T. U. and requires 6.05 cubic feet of air for combustion with a resultant mixture containing 91.7 B. T. U.

Water gas from retort coke contains 295 B. T. U. per cubic foot, and requires 2.35 cubic feet of air for combustion, with a resultant mixture containing 88 B. T. U.

Carbureted water gas has a calorific value of 575 B. T. U. and requires 5.25 cubic feet of air per cubic foot of gas for combustion, the resultant mixture containing 92 B. T. U.

Oil gas contains 846 B. T. U. per cubic foot, requires 8.07 cubic feet of air for combustion, and contains 93 B. T. U. in the mixture.

Producer gases from both anthracite and bituminous coals, while differing in analysis, have the same calorific value of 144 B. T. U. per cubic foot. The anthracite gas requires 1.12 cubic foot of air for combustion, and contains 68 B. T. U. in the mixture, while the bituminous gas requires 1.2 cubic foot of air, and contains 65.5 B. T. U. in the resultant mixture.

Producer gas from coke has an average value of 125 B. T. U. per cubic foot; requires 0.98 cubic foot of air for combustion, with a resultant mixture of 63 B. T. U. per cubic foot.

Coke oven gas has a value of 603 B. T. U. per cubic foot; requires 5.6 cubic feet of air for combustion, and contains 91 B. T. U. in the mixture.

Blast furnace gas has a heat value of 91 B. T. U., and requires 0.72 cubic foot of air for combustion, with a resultant mixture containing 53 B. T. U. per cubic foot.

The figures given for the air for combustion and for calorific values of the mixtures are based upon theoretical air required. It is interesting to note that where the original gases are not greatly adulterated by the admixture of an inert nitrogen constituent there are an almost constant number of heat units available per cubic foot of explosive mixture.

In considering the use of these various commercial gases for power purposes, we must briefly note:

Natural gas, very desirable for engine use, is restricted to special localities. Coke oven and blast fur-

*Journal of the Society of Chemical Industry.

nace gases, both desirable engine gases, are by-products of extensive industrial operations, and their production and utilization is subject to same.

Bench gas, oil gas, and carbureted water gas are all good engine gases, but are too costly for general use.

Water gas, as made in America, at least, is too expensive for general use, owing to the cost of raw fuel and the limited efficiency of the producing systems; in addition to this, is the apparent difficulty of its pre-ignition and back firing in the engine cylinder, due to its high percentage of hydrogen. This fact also prohibits that degree of compression which enables the system to operate at its highest efficiency. The raw fuel used in its manufacture is coke, and the process in general is similar to that employed in generating producer gas, except that the production of water gas is always intermittent.

In passing, it may be of interest to note that water gas processes are being exploited in Europe, which claim an efficiency of from 75 to 85 per cent in the conversion process—I refer to the Dellwik-Fleischer and the Kramers-Aarts systems. It has also been stated by the syndicates controlling these systems, that engine builders in Europe have overcome the difficulties of working on so high a percentage of hydrogen gas, that a number of engines are operating under a guarantee of a gas consumption not to exceed 31 cubic feet of gas per horse power hour, while tests show a consumption of less than 28.5 cubic feet. This, according to claims of the syndicates above mentioned, is a horse-power per hour per pound of coke, which they state they will guarantee.

If these statements are facts, it means that for the power problem, in certain special instances, we have another means of satisfaction. I do not refer so much to the generation of a gas for direct engine use (for coke in any one locality will always exceed in price that of an ordinary coal), but reference is made to the power problem in the vicinity of by-product coke works, where, instead of using 60 per cent of the gas given off by the coking coal for heating the ovens and having available a surplus of only 40 per cent for light or power purposes (or to let go waste as some of the plants now do) they make all the gas given off an available surplus by heating the ovens with water gas made from coke. In this way coke for which there may be no satisfactory market may be disposed of, and we have available from the coke plant at small cost a satisfactory engine gas which may be transmitted many miles without loss of energy and which may be utilized at any point or points along the distributing line for power. This, however, affects only the power problem in special fields.

For the general and average or the universal power plant proposition, it is evident from the brief *résumé* of the commercial gases outlined that it is the producer gas process alone which is susceptible of the development desired—a process capable of universal application, such as producer gas has already proven itself to be.

While producer gas is low in energy, it is a very satisfactory engine gas, the presence of considerable quantities of inert constituents having no detrimental effect upon the operation of gas engines other than occasioning the special designing of ports and passages to accommodate the large quantities of gas used. The efficiency of the various producer gas processes ranges between 70 and 85 per cent, depending largely upon the design of the producer and its ability in completing the gasification of heavy hydro-carbon distillates. It is the cheapest of all the commercial gases, costing less to generate, requiring the least amount of apparatus auxiliary to the generator, requiring less attendance and utilizing any available fuel to almost equal advantage—coke, coal, wood, the lignites, peat, and other materials have already been used successfully.

There are many variations in the methods and apparatus employed for generating producer gas. In general the process consists in simply passing air, or air and steam, through a body of fuel, inclosed in a suitable brick-lined generator; usually the process is a continuous one, fuel being fed as needed and the steam and air blasts being introduced simultaneously.

In the ordinary producer, when coke or anthracite coal are the fuels gasified, the gas comes off comparatively clean and requires little scrubbing for use in gas engines; when bituminous coal is gasified the gas is extremely dirty, and contains a large amount of tarry vapors, so that it is necessary to thoroughly scrub it before it is adaptable to engine use.

It is because of this difficulty—the necessity of extensive scrubbing and cleaning systems with gas made from bituminous coal—that practically all our producer systems, generating a gas for engine use, operate on anthracite or coke.

A typical analysis of producer gas from anthracite and bituminous coals and coke is that indicated in the foregoing table; both the coal gases have a calorific value of 144 B. T. U. per cubic foot, while the coke gas has a value of 125 per cubic foot. This difference in heat value is due to the raw fuel used and the resultant necessary methods of gasification—notably the amount of steam introduced and decomposed.

All three gases show about 5 per cent of carbon dioxide, owing to the burning of some of the carbon monoxide, but to make a gas even of the above analysis demands that the producer be kept in the best working condition and handled with skill.

It was stated that the efficiency of the producer gas process varied from 70 to 85 per cent, according to methods and apparatus employed. The efficiency in any instance may be determined by dividing the net heat output by the gross heat input; or calorific value of gas per cubic foot × gas yield per pound of fuel ÷ calorific value of fuel used per pound.

As an example of the efficiency attained in average producer practice it may be interesting to call attention to a summary of investigations for producer practice made at the works of the Pennsylvania Steel Company, Steelton, Pa.

The coal used was bituminous, containing carbon 75.68 per cent, ash 7.12 per cent, moisture 4.00 per cent. Its heat value per pound was 14,920 B. T. U. The amount of gas made per pound of coal was 70.15 cubic feet. Its composition by volume was (dry gas)—

CO_2	5·7
CO	22·0
CH_4	2·6
C_2H_4	0·6
H	10·5
O	0·4
N	58·2

Its calorific value per cubic foot was 154.5 B. T. U. The efficiency of conversion was 78.4 per cent as follows:

	Per cent.
Amount lost as carbon in ash	2·1 of value of coal.
Amount lost by radiation and conduction	5·1 " "
Amount lost in sensible heat of steam	0·7 " "
Amount lost in sensible heat of dry gas	13·7 " "
Amount of total loss	21·6 " "
Amount made available in producer gas	78·4 " "
Total value of coal	100·0 " "

Before noting the several methods and various types of apparatus used for generating producer gas it may be interesting to point out what is desirable in the way of a producer.

First of all, we would like to have a continuous gasification process, or, as was previously noted, a process that involves the least possible alteration of condition affecting generation; it must be a process and apparatus capable of wide demands in the way of output without serious variations in the quality of the gas; the variable loads of general power service demand this.

The producer or generator should be provided with a continuous fuel feed in order to preserve therein a uniform depth of fuel; this feed and its mechanism should be positive, adjustable, and easy running.

The producer should carry a fuel bed of considerable depth to insure uniform gas and complete gasification; and means should be provided for maintaining a loose fuel bed and preventing packing so that the resistance to the blast and the irregularity of the process may be minimized.

An ash bed of sufficient depth to prevent loss of good fuel and of internal heat, should be kept beneath the fuel bed; means should be provided for the removal of ashes without detrimentally disturbing the fuel bed.

The steam and air blasts should be so introduced as to secure uniform distribution below the fuel bed and throughout its whole body.

In addition to this we would specify for this producer a requirement which no single producer or generator on the market can now satisfy. It should be so constructed that by a simple operation it should effect the complete conversion into fixed gases of all the combustible constituents of bituminous coal, and deliver a gas for engine use that needs no cleaning other than the removal of dust.

As regards the various types of producers now in operation, they all consist essentially of a cylindrical steel shell lined with fire brick and provided with a sealed coal feeding hopper at the top; a gas offtake at the top or bottom; a central or transverse *tuyère* for the steam and air blast and a fixed bar grate or a revolving bottom, or water seal, for removing ashes while the producer is in operation.

There are four distinct methods of operation and a consequent modification of producer design to satisfy them, viz.:

Producers operating to furnish an engine gas, under the first method, successfully handle anthracite coal and in some cases also the semi-bituminous coals, provided the proper additional scrubbing appliances are used for the latter.

The second method is a recent development, and has for its object the generation of a gas at the precise rate demanded by the load upon the engine; and for this purpose the engine is arranged to furnish the required suction at the producer, upon its inspiration stroke. In employing this method, coke or anthracite fuels alone are the materials gasified.

The re-entrant method was adopted for bituminous coals with the object of gasifying the tar vapors within the producer. By this method the gases are not taken off from the top of the generator, but from openings considerably below the top of the fuel bed and about half-way down the chamber walls. It is claimed that the green coal in the upper part of the producer undergoes distillation to the coke stage; and the liberated tar vapors, which are forced to descend through the hot fuel bed to reach the outlets, are largely broken up into fixed gases, but this is only partially true, for it is admitted that the method is not suitable for gasifying coals of a strongly coking nature.

The last-named method, the intermittent system, as developed in the Loomis-Pettibone producer, is the only method in producer practice by which we can satisfactorily gasify bituminous coals and produce therefrom a gas suitable for engine use without extensive auxiliary cleaning apparatus. Two generators are employed, connected in series at the top, and provided with independent outlets at the bottom.

In general, the process follows that of water-gas making; on the blow the generators operate in parallel; air enters at the top of the generator and comes into contact, first, with the fresh fuel; the products of combustion, together with any distillates from the fresh fuel, are drawn downward through the deep charge of incandescent fuel and out through the bottom of the producer; they then pass through the boiler, where their high temperature is utilized to generate steam; they are further cooled to about atmospheric temperature in their passage through the water-sprayed, coke-filled trays of the scrubber, whence they pass to a special holder.

When the fuel bed has been raised to the desired temperature, the air blasts are discontinued; and, after adjusting the valves and throwing the generators in series, steam is admitted under the grate in one generator and is dissociated at the temperature of the fire, forming water-gas on its passage up through the hot fuel bed, across the top connecting pipe to the second generator and down through the latter; it then passes out from the bottom of this generator to the boiler, the scrubber and water gas holder. The next time water gas is made the direction of the run is reversed—the advantage of which is evident. The gases are finally properly mixed in the desired proportion.

The essential feature of this arrangement and process is, that with bituminous coals, the tar vapors, liberated from the green fuel in one generator, are forced through the hot fuel bed of the second generator, where they are converted into fixed gases.

This system has other important advantages. While two generators are employed the apparatus of the plant is compact, simple, and efficient in operation, and it readily adjusts itself to varied and wide demands; and, when applied to gas generation for power purposes, has proved itself capable, under all rates of production, of maintaining those nearly uniform conditions in the fuel bed which are essential to a gas of uniform quality.

(To be concluded.)

A NEW PROCESS OF STERILIZING CORKS.

Our contemporary Prometheus has recently described a novel method of destroying the germs in corks, which may be not without interest to our readers. As is well known, cork possesses a number of very valuable properties, such as an extraordinary degree of elasticity, imperviousness to liquids and gases, great durability and low specific gravity; nevertheless it has one serious defect which renders it ill-adapted for certain purposes. We refer to its porosity which, especially in the inferior grades, is greatly increased by the presence of more or less cork meal. This mealy material results from the disintegration of the stone cells which penetrate the cork fiber, and falling to a powder facilitate the entrance of infection. After micro-organisms have once gained a foothold in the pores, it is extremely difficult to dislodge them. Boiling in water impairs the quality of the cork, without completely destroying the infecting germs. The water thus imbibed by the pores is squeezed when the cork is inserted into the bottle and may thus give rise to an infection of the contents. Prolonged steaming of the corks does eventually kill all the germs, but also causes the corks to shrink and deprives them of their elastic character. The most effective means of sterilizing corks now practised consists in paraffining; it closes the pores, but does not destroy all the germs.

The process described in Prometheus employs an apparatus devised by H. Gronwald and called by him "Supersanum." It effects the cleaning and sterilizing of the corks and then impregnates them with a special mixture. To remove the cork-meal the corks are dried, then placed into a wire basket which is suspended in a double-walled cylinder into which steam may be injected. By means of a centrifuge the cylinder may be revolved, so that the corks are freed from the meal by centrifuging. They are then sterilized by treatment with the vapors of formol and ethyl alcohol and simultaneously steaming. In this way, it is claimed, all germs are effectually destroyed. The sterilized vapors are now displaced by germ-free air, and the melted impregnating material introduced into the cylinder. The centrifugal motion is said to promote the thorough impregnation of the corks and, at the same time, to remove any excess of the melted material. After cooling, the corks are ready for use. The inventor claims that his process has been thoroughly tested, and if this claim is borne out in practice, it will probably find extended application, especially since the cost of this method of sterilizing is very small.

During the latter part of the eighteenth and throughout the nineteenth century the extensions of all branches of physical science so enlarged their fields of application that the foundations were laid of another distinct and prominent faculty in universities. The great investigators in chemistry, in physics, in biology, and in the marvelous combinations and ramifications of those and other affiliated sciences were the pioneers in the service rendered by science to the creation of the industries of the world which have been such potent agents in the extraordinary advancement of civilization during the past one hundred and fifty years. Every addition to scientific knowledge, meaning simply a closer contact with the realities of our natural environment, has supplied a corresponding field of activity for useful effort and in just that much has enlarged the meaning and the volume of life.

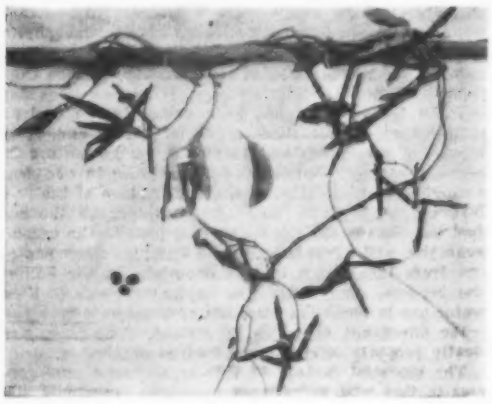
[Concluded from SUPPLEMENT No. 1614, page 25861.]

HOW SEEDS ARE CARRIED.—IV.*

IV. SEEDS SCATTERED BY PROPULSION.

By CRAIG S. THOMS.

MANY plants, such as Canada violets and jewel-weeds in woods, hoary vervane and beard-tongues on the prairie, and catnip and Indian mallow in waste places, are found in quite dense colonies, yet not too dense for vigorous growth. Their seeds, though not



SEED PODS OF WILD BEAN. IN THROWING SEEDS, THE PODS CURL.

carried far, are nevertheless flung a little way from the parent plant.

Some of these plants, and others whose seeds are propelled in the same or similar ways, bear seeds so numerous that if all grew where they fell there would not be room for any of them to mature. By careful calculation I have estimated that upon a single plant of the catnip there were over 40,000 seeds, and upon a single stalk of the tall bellflower at least 15,000 seeds—the latter calculation being made in mid-winter when part of the seeds had been thrown out.

Prof. Kerner, of the University of Vienna, has found that a plant of black henbane bears about 10,000 seeds annually; that one of the mustards (*Sophia*) bears about 730,000. He has calculated that if every seed of henbane produced a plant each year for five years the plant would cover all the dry land on the earth, and that under similar conditions the mustard in three years would cover two thousand times as much land as the earth has.

Of the millions of seeds cast upon the ground only two or three in a thousand find conditions of growth. With many plants, therefore, especially those which have small, light seeds, it is necessary that the soil about them be sown very thickly if the resulting plants are to grow near enough together to have speaking acquaintance.

When certain plants are ripe the bursting of the seed capsule projects the seeds a little way. If one will pick off the globular seed vessels of ripe garden phlox and place them in a dish in the middle of a dry room he will not have long to wait before finding them scattered over the floor—not only the seeds, but the seed capsules as well. Upon ripening these capsules acquire tension which when released by the bursting sends the seeds flying three or four feet.

Though the seed vessel of the wood sorrel is made on a different plan, the seed is ejected in much the same way. The inner layers, being of high tension, finally burst the capsule and send the seed out like the bullet before an exploding charge of powder, though, of course, with little force, since the seed is sent only a few feet.

Certain plants, like the jewel-weed or touch-me-not, eject their seeds upon being touched by any person or animal. In this way the seed is not only shot out a little way, but has a chance of being lodged in the fur of some animal and carried a considerable distance.

Certain of the violets remind one of a roguish boy snapping cherry stones from between his fingers. The seed vessels separate into their three divisions which, though lying back and exposing the seeds, yet remain attached at the base. Then, first in one division, then in another, and finally in the third, the sides of the boat-like divisions begin to contract and pop the seeds out one by one, always in regular order. Before this operation takes place the stalks bearing the seed vessels straighten up to their fullest height, and the seeds are usually popped out at an angle of about forty-five degrees, which is the angle of greatest propulsion.

A still more curious arrangement is found in the common crane's bill. The five seeds are arranged about the base of a cone which is made up of five extended seed capsules all attached together at the top. Each of these holds a seed at its base. When the seeds are ripe each of these long capsules dries most quickly, of course, on the outside, and in drying contracts, thus producing a tension which finally detaches the seed from the base and jerks it upward and outward with such force as to throw it four or five feet.

While these woodland flowers usually grow in colonies more or less dense, any of them may occasionally be found growing singly and much farther from a colony than the plants could possibly project the seeds. This is especially true of the crane's bill, which is not infrequently found growing all alone. To be sure, its seeds are not many, and each one growing singly may be the last of an old but gradually decreasing colony; but I have wondered if birds in their search for gizzard-stones with which to grind their food, might not pick up many of these small, hard seeds and excrete them uninjured at a distance from the plant.

There is a large variety of plants which project their seeds by means of tall, slender, resilient stems. These for the most part are found in open places where the wind can sway the stems back and forth, or bend them quickly with a sudden gust.

One of the best known of this class is the familiar sunflower. In its broad heads each large, heavy seed lies incased on three sides with a chaffy scale about

SEED PODS OF BEARD-TONGUE, SHOWING HIGH POINTS OVER WHICH SEEDS MUST BE THROWN.

twice its length and pointing upward, or nearly so. It requires quite a strong wind to dislodge the seeds, for, though the plants often grow six or eight feet high, the stems are strong and stiff. When the plant is bent with sufficient suddenness and force to send the seeds flying, the elongated, chaffy scale inclosing each one, gives them proper direction, like rifle barrel to bullet, and, like long bullets also, the seeds are projected endwise, which enables them to encounter the least possible resistance from the air.

In the catmint the flowers grow in dense, clustered spikes at the ends of quite tall stems. The persistent calyxes, each of which holds four tiny seeds at its base, are set at right angles to the stem, and thus point horizontally. A close examination of these calyxes, however, will reveal the fact that the lower side is curved so as to give the seed when it is thrown out an upward shoot. This adds materially to its projection distance.

It is quite generally true of ripe seed pods that they open on dry, windy days and close upon wet

A HEAD OF GARDEN PHLOX ENLARGED. THE BURSTING OF THE SEED CAPSULES SCATTERS THE SEEDS.

ones. Of this there is no better example than the Indian mallow, whose hairy pods upon rainy days close tight their gaping exits, not only to keep the water out, but the seeds in.

For the farthest projection of seeds the insides of pods must be dry and smooth, for only upon such a surface do they meet the least resistance. It is necessary also that the wind be strong so as to shake the plant with violence, and such winds occur, except in an occasional downpour of rain, usually upon dry days.

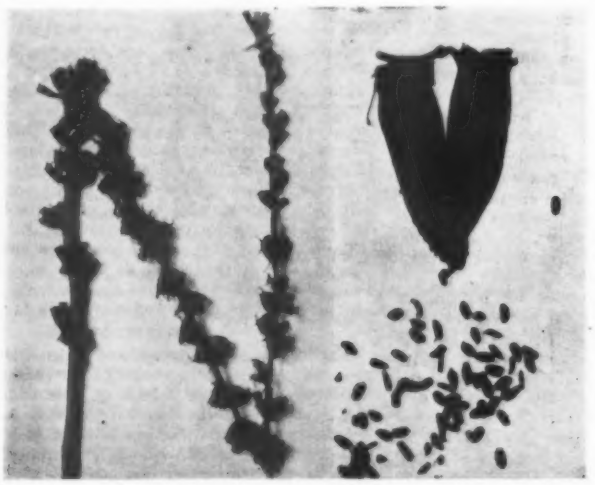
For giving the seed its proper direction the Indian mallow capsule is specially well fitted. The upward shoot of about forty-five degrees is given by the shape of each pod, and the way it is set upon the stem, while the seeds are kept in a straight-ahead direction by long awns which guard the sides of each capsule opening.

So far the plants mentioned have arrangements for scattering their seeds, which indicate a willingness to part with them, but a few may now be mentioned whose arrangements would at first seem to indicate the very opposite.

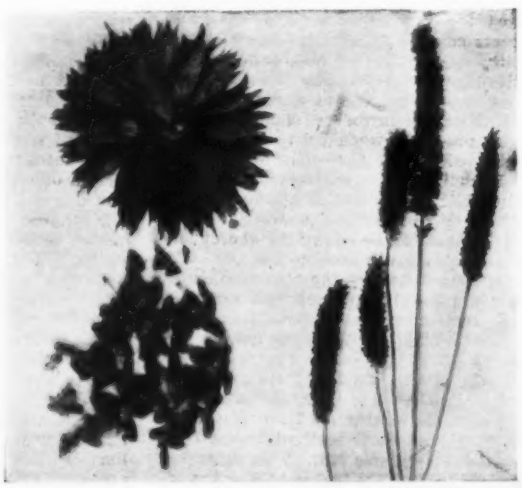
The large-flowered beard-tongue has seed capsules which point straight upward and open only at the top. Not only so, but this opening is guarded by four long pod-points. It is evident that the seeds would be thrown out much more easily if the pod-points were turned farther back, and if the pods themselves were set at an angle farther from the perpendicular. Not ease, however, but distance is what Nature is seeking. It requires a strong wind and violent shaking of the plant to send the seeds out over the long, perpendicular points, and when thrown out, the strong wind itself hurls the light seeds much farther than the plant could project them.

An instance of like character is seen in the Carolina milk vetch. The oval seed capsules hug their stem as tightly as possible and open at the top only on the inner side. The seeds are thus held until a strong wind sways the plant with sufficient violence to send the seeds out over the back of the capsule opening.

The strangest arrangement, however, is seen in the seed capsule of the tall bellflower. Near the top, and corresponding to the three divisions of the seed vessel, are three tiny holes, one on each side of the triangular capsule. These holes are just large enough to let the seeds out one at a time. In the plant shown in the illustration there were two hundred and fifty-



THE TALL BELLFLOWER SEED CAPSULES. IN THE ENLARGED CAPSULE NOTE THE SMALL SEED OPENINGS AT THE TOP.



CAT MINT SEED HEADS, SHOWING ENLARGED CROSS-SECTION OF A GROUP; ALSO ENLARGED SEEDS.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

nine seed capsules, from one of which were taken seventy-five tiny seeds. This would give over 19,000 seeds. And it is evident that, being let out one by one from each capsule division, many high winds from many directions would be required to scatter them all. Such a holding on to seeds and letting

THE SEED PODS OF A VIOLET, SHOWING HOW THE SEEDS ARE POPPED OUT. (DRAWING BY SHERIDAN JONES.)

them out gradually under high winds, gives to a plant a decided advantage. The slowness of their distribution secures wind from many directions, and the difficulty of their expulsion requires winds that act on the plant with such violence that the seeds are propelled as far as possible, while such winds, of course, carry the seeds when expelled to considerable distances.

It must not be forgotten, as stated in a former article, that aside from the means of distribution here pointed out, these seeds are often carried also by water or drifting snow.

A means of propulsion with which the wind has little to do is seen in the leguminose family, of which the wild bean is a good example. Diagonally across the pod run rows of cells which in drying twist so as to produce outward tension. This tension at length becomes so great that the halves of the pod are torn violently apart and twisted up in rows so suddenly that the seeds are scattered in every direction. By touching lightly on the tip a pod that was ready to burst, I have seen these seeds thrown five or six feet. This was from a pod which hung about five feet from the ground.

The wild bean is also one of those plants whose seeds are carried some distance by the running of the vine. Of this class perhaps there is no better example than the wild cucumber. The rapid growing of the vine often drops the new seed twenty or thirty feet from the place where the old one fell. Then, the light seed pods, which are strung on slender stems, are driven back and forth by the wind so that the large, flat seeds are most apt to be shaken out on windy days when they may be hurled to some distance.

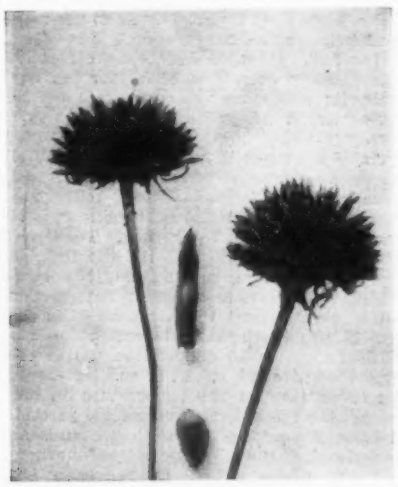
In the same way—by growth of vine—are scattered to some extent the seeds of all vines—grapes, woodbines, morning glories, pumpkins, and hosts of others.

But when all that we can learn has been said about seeds that fly, that tumble and float, that are carried by animals and birds, and that are propelled, we are often puzzled to know whence and how seeds come into unexpected places and find their way far from others of their kind.

YELLOW FEVER AND SANITATION.*

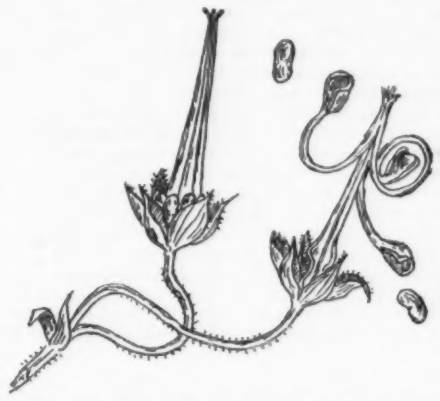
By J. N. HAZLEHURST.

THE first opportunity in the United States for test-



SUNFLOWER HEADS, WITH ENLARGED SEED AND CHAFF.

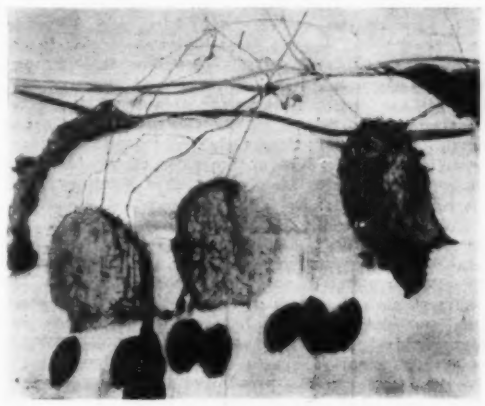
ing the "mosquito theory" came during the summer of 1903, at Laredo, Texas, from infection traced to Tampico, Mexico. At the time, Laredo contained a population of some 18,000, residing on the Texas side of the Rio Grande River, and about 8,000 persons living in the Mexican section. Neither town possessed either storm or sanitary sewers, and their water supply was furnished by a chartered corporation from the turbid river, and was deficient both in quantity and quality, while the rates were such as to render its general use impossible to the poorer inhabitants and its character



SEED POD OF CRANE'S BILL, SHOWING HOW THE SEEDS ARE THROWN. (DRAWING BY SHERIDAN JONES.)

such as largely to forbid its consumption by others, hence the almost universal use of cisterns, casks, and other receptacles, concerning which the Marine Hospital surgeon officially reported that "as a breeding place for mosquitoes and especially the *Stegomyia fasciata*, it would be difficult to improve upon them." In the same report, he also stated that this species was found in enormous numbers and widely distributed.

Shortly after this outbreak, the Marine Hospital authorities assumed control, immediately inaugurating the then experimental work of fumigating buildings; screening cisterns and the oiling of pools, gutters and



SEEDS OF THE WILD CUCUMBER.

other likely breeding places of mosquitoes. According to an official report, "so thoroughly was the work of destroying mosquitoes, and especially the work of oiling containers and other breeding places performed, that an officer of the Service detailed in Laredo to study infected yellow fever mosquitoes, could not find, after diligent search, enough *Stegomyia* in the adult, larval or pupal stages to carry on his work."

In Laredo, from September, 1903, to March, 1904, there had been upward of a thousand cases of yellow fever with about ten per cent mortality, but for the first time in history, the disease had been conquered before a killing frost.

During the late epidemic in New Orleans, similar conditions largely existed, only a limited section of the city being provided with sub-drainage, while all portions of the city were without sanitary sewers. The distributing system of the water works was entirely inadequate and the water supply, being unfiltered, carried in suspension ordinarily as much as four tons of sedimentary matter to each million gallons of water, resulting in the almost universal use of cisterns, casks and such containers, as may be inferred from Dr. White's report that at the commencement of the epidemic there were in use in the city of New Orleans sixty-eight thousand cisterns. Despite the headway gained by the fever there before the commencement of remedial action, and the adverse sanitary conditions, after 3,390 cases of yellow fever, resulting in 459 deaths, the disease was eradicated and all quarantine restrictions removed for more than a month prior to the first heavy frost. While the triumph of science was again complete, the costs of victory were heavy, several hundred thousand dollars having been expended during the campaign, while indirect losses could hardly be estimated.

From the record of the past two facts have been absolutely demonstrated.

First, that complete isolation and non-intercourse from and with the outside world, to be secured through unceasing vigilance, can prevent a first infection of any community without the tropics. Second, that after infection and even under the most unfavorable circumstances and conditions energetic remedial measures directed upon scientific principles as now understood will control and effectually stamp out any epidemic of yellow fever. While these facts are comforting assurances and mark a distinct advance, it is prevention rather than cure which should occupy the attention of those in authority, otherwise our cities, towns and villages, situate within the life-zone of this deadly peril, are forever doomed by fear of this introductory spark and through the instinct of self-pres-

SEED CAPSULE OF THE WOOD SORREL, EXPELLING THE SEEDS. (DRAWING BY SHERIDAN JONES.)

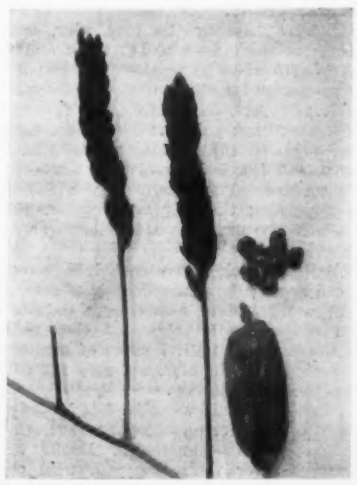
ervation to maintain a costly and barbarous "shotgun" patrol with the ever present possibility of accidental infection with all of its attendant hardships and misfortunes to stricken communities. Students of this subject can hardly fail to become impressed with certain facts in connection with the recurrence of yellow fever in the United States since its first entry; first, that while yellow fever formerly raged in many of our northern sea-port towns, it has made no visitation north of the Mason and Dixon line for so many years that apprehension as to such epidemic in those sections of the country no longer exists. Second, that while formerly an epidemic in the South continued its spread into nearly every city until its course was checked by frost, since 1878 fewer cities were invaded and that certain cities, often far removed from each other, seemed to suffer under peculiar fatality in respect to its attack. Science must discover some reason for these facts.

An explanation given by Dr. J. H. White, of the Marine Hospital Service, as to the disappearance of yellow fever from northern cities is certainly entitled to respectful consideration, and is as follows:

"It would be a false claim, if set up by any of our great northern cities, that, with municipal utilities which appealed strongly to their ideas of creature comfort and general cleanliness, and which incidentally and entirely accidentally eliminated the mosquito at the same time. These public utilities were a thoroughly controlled water supply, sewerage, drainage and pavements, and these four, not one, but all of them, were essential to the end attained."

Dr. White's contention is that although accomplished accidentally, the agencies directly responsible for the elimination of yellow fever were the introduction of those public utilities which prevented the propagation of the mosquito.

Let us consider the evidence in support of the fact that these same agencies may be relied upon to prevent the recurrence of yellow fever within the section now known to be the habitat of the insect responsible for the spread of this disease. Parenthetically it may be remarked that seldom does the construction of water-works, sewers, and street pavement occur simultaneously, but generally in the following order. First, water-works are built; secondly, sewers are demanded to remove the waste water of the water supply, and



SEED PODS OF CAROLINA MILK VETCH; POD AND SEEDS ENLARGED.

lastly, after water and sewer pipes are laid, the streets are paved, the surface drainage being an incident of this latter construction.

After the epidemic in Memphis during the year 1878 when, according to Keating, some 17,600 cases of yellow fever occurred, resulting in 5,150 deaths, and

* Extracts from a paper before the American Society of Municipal Improvements.

the return of this disease the year following, Col. George E. Waring, C.E., was retained to design and construct a system of sanitary sewers, the first comprehensive application of the separate system upon this continent. Concerning the potentiality of these sewers in the prevention of another disaster from like cause, Col. Waring made the following remarkable prophecy in his address before the American Public Health Association, at Nashville, Tenn., November, 1879:

"I trust that, as I am neither a Southerner nor a physician, I may be excused for attaching more importance than many of you probably do to the proper drainage and cleaning of a city, and to the proper disposal of its outflow, and more than to any system of quarantine. My knowledge of the history of the yellow fever epidemics in this valley is infinitely less than yours, but I feel warranted, and I take my warrant from the history of the plagues which devastated the filthy mediæval cities of Europe, and from my own knowledge of the want of cleanliness and want of drainage in the city of Memphis, in venturing the suggestion that even that fever-smitten town may be made an impossible field for the invasion of yellow fever in epidemic form."

While Col. Waring's theories probably had few converts, the necessity of doing something toward securing relief from this scourge drove the people of Memphis to commence its sewer system which now comprises 210 miles of sanitary, and 4 miles of storm sewers.

Since the first work was inaugurated, Memphis, although frequently menaced, escaped any attack of yellow fever until the year 1897, when the plague being general throughout the Mississippi valley, 50 cases and 15 deaths were accredited to Memphis.

From a population of 33,592, according to the census of 1880, that city had grown to 102,320 inhabitants in 1900. From a recent letter from the City Engineer of Memphis regarding the fever conditions there in 1897, the following is quoted:

"Regarding fever conditions here in '97, beg to say I have investigated the matter and find that we had 50 cases and 15 deaths. All of these cases were distinctly traceable to one locality except one which was shown to be imported from New Orleans. The infected district was unsewered. It was inhabited principally by people of the lower class. It was partly paved and had water connections."

Before the year 1880, no city in the South had more than a most fragmentary system of sewers, but after the example set by Memphis, the larger towns one by one inaugurated more or less extensive and comprehensive systems of sewers, until of the principal cities there remain unsewered only New Orleans, Vicksburg, Pensacola, and Galveston.

Systematic effort has been made by the writer to secure statistical information as to paving, sewerage, water-supply and like municipal improvements of all the cities located within the fever-zone, and as well, the dates since 1878 showing recurrence of yellow fever in each.

Reports from more than twenty such cities show that, exclusive of Memphis, whose experience has been recited at length, only four towns have been afflicted with yellow fever since the construction of systems of sanitary sewers. These towns are Montgomery, Ala., Natchez, Miss., Baton Rouge and Alexandria, La.

The most important of these towns is Montgomery, whose sewers were constructed in 1889, and despite which it suffered from fever in 1897, 134 cases being reported during that year. At the time these sewers were constructed, the city had a population of only about 20,000, and this had expanded to more than 30,000 at the time when the epidemic occurred. It is also reported that the fever at that time existed only in sections of the city which were unsewered and that no case was recorded within the sewered districts, indicative of the fact that the city had outgrown its first sewerage works.

Natchez, Miss., during the past year, suffered by yellow fever to the extent of 143 cases and 7 deaths. This city has 45 miles of unpaved streets; 7 miles of sanitary sewers and 2 miles of storm sewers. According to official report, only two cases of yellow fever occurred in dwellings provided with sewer connections. It is also reported that connection to sewers is not compulsory, and few such have been made. The sewers were constructed and owned by a franchise corporation supplying the city with water. Numerous cisterns are in use owing to a deficient water distribution and supply.

Baton Rouge, which also reported 10 cases of fever and 1 death during the past epidemic of fever, has also a deficient water system, owned by a private corporation, and relies also largely upon cisterns and like water containers. In 1901, 7 miles of sanitary sewers were constructed by the city, but only 150 connections have been made voluntarily.

Lastly, the town of Alexandria, La., built its 9 miles of sanitary sewers during the year 1900, and in this town, connections are compulsory. During 1905, nineteen cases of fever were returned, with one death. Concerning conditions there during the fever continuance, the city engineer writes as follows:

"While city water is generally used, a considerable number of the population have tanks, cisterns, and barrels for gathering rain-water. . . . The spread of the fever in this place seems to have been due entirely to the quite extensive use of cisterns which were not screened, and so formed breeding places for the mosquito."

Alexandria is built upon ground extremely low and flat, and open canals and ditches are relied upon to remove the storm-waters. It is especially worthy of note that during the epidemic of 1905, New Orleans, Vicksburg, and Pensacola were the principal sufferers, cities deficient in sewers of all descriptions, and in contrast, during the same year refugee or imported cases of fever occurred in Montgomery, Ala., Tampa, Fla., and Shreveport, La., cities which in the past from such infection would undoubtedly have been quick to respond, but no spread of the dread disease occurred. It is significant that these three cities have been effectually sewered and connections are made compulsory. If such statistical facts are considered merely coincidences, in further support of the theory that sanitary sewers, especially when augmented with an abundant and suitable water supply may be relied upon to prevent the spread of yellow fever, the cases of Vera Cruz, Merida, Yucatan, and the city of Havana may be cited. The first of these cities was sewered and paved about three years since, and although for generations, each year witnessed an outbreak of yellow fever, whose virulence was limited only by the extent of the immune population, few cases and no epidemic of yellow fever have since been reported. The city of Merida, following the example of Vera Cruz, has lately expended something more than four millions of dollars upon her public utilities. This city of the tropics, accustomed each year to reckon the victims of yellow fever by the hundreds, reports only 10 cases of fever for the fiscal period, accounted for by a recent press dispatch as follows:

"This great improvement is due to the improved system of isolation and the institution of modern sanitation."

But that isolation alone may be expected to fail in providing adequate protection may be well suspected from the late experience in Havana, a city where this method of protection may be admitted to have reached its highest development. Infected from the epidemic of 1905 at New Orleans, and despite the most active efforts of its health officers, yellow fever made marked progress there, and resulted in the establishment of quarantine restrictions against that city upon the part of North and South American sea-ports. Havana has no system of sewers.

In view of the evidence submitted, the deduction seems warranted by the facts that even a city in the tropics may be freed entirely of yellow fever by providing modern municipal utilities, and the potentiality of these agents must be far greater when applied to communities where yellow fever is known to be exotic, hence the writer feels fully justified in the assertion made by him at the close of the campaign inaugurated by the Mobile Auxiliary Sanitary Association, as follows:

"What has been written is not intended to belittle or detract from the intelligent effort of our local health board in its successful maintenance of scientifically formulated quarantine regulations, nor to underestimate the work accomplished by this association, but that the fever has not fastened upon our city, seriously menaced though it were, is probably neither a miracle, due to a special dispensation of Providence, nor to the preventive and remedial measures exercised during the present crisis. While each has done what he could, with the previous installation of a bountiful water-supply and the construction of a comprehensive system of sewers, followed by the completion of a considerable area of street paving, exercising reasonable prudence and precaution, no longer need Mobile tremble at the outbreak of fever in this section, for danger from this source has passed for all time."

THE GAS-TURBINE AND THE TURBINE-COMPRESSOR.*

IT has long been known that the solution of the problem of the gas-turbine was, to a large degree, dependent upon the solution of that involved in the construction of a satisfactory rotary compressor. A somewhat special interest attaches, therefore, to a contribution made by M. Rey to the proceedings of the Société des Ingenieurs Civils de France, in which, in discussing the prospects of the gas-turbine, he states some of the results obtained with a very fine Rateau turbine compressor, constructed by MM. Sautter, Harlé et Cie. for the Compagnie des Mines de Béthune. The compressor was designed to compress 2.2 pounds of air per second (1,716 cubic feet of free air per minute) to a pressure of 7.2 atmospheres absolute. On trial it actually gave an output greater by 25 per cent, the speed being 4,500 turns per minute, and on increasing this speed it was found possible to augment the pressure of discharge by another atmosphere. The compressor is divided into four distinct parts, each consisting of a group of thirty-two independent compressors arranged in series on the one shaft, an intercooler being intercalated between each successive pair of these groups. In the first group the pressure was raised up 1.7 atmospheres absolute, while the pressure of discharge from the second group was 2.9 atmospheres absolute, and from the third 4.9 atmospheres absolute. The machine required 400 horse-power to drive it.

The measurement of the internal losses of a turbine compressor is a peculiarly simple matter, it being solely necessary to read the temperature and pressure of the air as received from one intercooler, and again after it has passed through the next compressing group and before it enters the next intercooler. All the frictional losses in that part of the compressor between the two intercoolers concerned go to heat the air acted on, which, therefore, attains a temperature in excess of that due to adiabatic compression. Knowing the specific heat of air at constant pressure, the heat value of this rise of temperature is immediately obtained, and this gives in heat units the whole of the internal losses in the portion of the compressor under consideration. We do not know who was the first to hit upon this very simple method of determining the efficiency of a turbine air-compressor, but it has been used in this country by Mr. H. A. Humphrey, M. Inst. C.E., and M. Rey we note used it in determining the efficiency of the large Béthune compressor above referred to. In this way he found that the efficiency of the first group was 70 per cent, and that of the last, or high pressure, group 53 per cent, the mean efficiency for the whole four groups being about 63 per cent. The lower efficiency of the high-pressure group is presumably due to greater losses by fan action, and also, perhaps, by greater leakage past dummies into the open air. The results above obtained are certainly remarkably good, the best results we have hitherto met with in such compressors being about 60 per cent, the efficiency being measured in the manner above explained.

In several respects a compressor works under much less favorable conditions than a turbine. In the latter some of the work expended in friction in the upper stages of a group is available for doing work in the succeeding stages. In the compressor, on the other hand, the work expended in friction in the earlier stages goes to increase the volume of the fluid by the heat generated, and thus to augment the work which it is necessary to do in the succeeding stages. Hence, other things being equal, the thermodynamic efficiency of the turbine should exceed that of the compressor. Again, in a turbine the operation consists essentially of the conversion of "pressure head" into "velocity head," while in the compressor the transformation effected is the reverse of this. Now all experience in hydraulics goes to show that it is much easier to effect efficiently the transformation first-named than the second. An ordinary turbine driven backward makes a very poor centrifugal pump. The conversion of velocity head into pressure head implies that the fluid flows through a diverging channel, the losses in which appear to be invariably greater than when the flow is converging. In some experiments by Dr. Stanton, of which an account was given in our issue of November 21, 1902, it was found that even with angles of divergence less than 6 degrees the loss was from two or three times as great as when the fluid passed through an equal length of a converging channel, while with large angles of divergence the loss augmented with very great rapidity. Rapidly converging nozzles appear, on the other hand, remarkably efficient. It would seem, therefore, that a turbine-pump of any kind must always be somewhat more cumbrous than the corresponding turbine, the necessity of slow divergence, if the conversion of "velocity head" into "pressure head" is to be economically effected, making essential the use of channels which are long relatively to the pressure difference established in them. This view is very well borne out by the Béthune compressor, each group of which measures over 6 feet 6 inches in length, or over 26 feet in the aggregate. From the foregoing consideration the 70 per cent efficiency attained with the low-pressure group of this compressor appears exceedingly good, and will not easily be surpassed.

In passing we may note that the output of this compressor was determined by causing it to discharge back into the atmosphere, through a convergent nozzle. Repeated experiments have shown that when the outer pressure is less than half the internal pressure, the coefficient of discharge for such a nozzle is practically unity, the weight of air passed per second agreeing with almost absolute accuracy with that calculated on the assumption that the pressure at the point of exit is 58 per cent of the internal pressure. A somewhat similar method of measuring discharges has long been used in this country, the air being passed through a sharp-edged circular hole in a flat plate. Here, however, there is no little uncertainty as to the true value of the coefficient of discharge, though it is often taken as equal to 0.60. It would seem, therefore, that whenever the pressure drop is sufficient for the discharge to obtain its maximum value, the use of the converging nozzle, as adopted by M. Rey, has many advantages.

As pointed out above, it would seem that an efficient turbine compressor must be relatively large and cumbrous, and this factor would always militate against the commercial success of the gas-turbine, even if there were no other difficulties in the way. These are, however, by no means negligible. In the first place, a very high temperature is desirable if a reasonable over-all efficiency is to be attained; but practical considerations greatly limit what is possible in this connection. M. Rey states that in steam-turbines mechanical considerations make difficult the use of steam at temperatures above 570 deg. F. or so. No copper alloy will, he states, stand such a temperature for long, and even nickel steel deteriorates unless the percentage of nickel is very considerable. High pressures are also highly desirable if a good commercial economy is to be attained with a gas-turbine. On the other hand, no turbo-compressors have yet been built compressing to more than about 120 pounds per square inch, and the figures above given for the Béthune compressor indicate, so far as they go, that the losses will increase as the pressure rises.

Taking matters as they stand to-day, and assuming the efficiency of both turbine and compressor at 65 per cent, and the working pressure as 7 atmospheres,

* Engineering.

M. Rey finds that the compressor would require to drive it some 88 per cent of the whole output of the turbine, so that the margin available for doing useful work is almost a vanishing quantity. The conditions are actually rather less favorable than stated, since, to give the plant every advantage, M. Rey has assumed that it will be possible to work the turbine blades at a temperature somewhat above that at present found practicable, or at about 800 deg. F. Any improvement in these figures can only be obtained by the adoption of higher working pressures, or by a considerable improvement in the turbine efficiency.

A MAGNETIC INDICATOR OF TEMPERATURE FOR HARDENING STEEL.*

By WILLIAM TAYLOR.

THE well-known troubles of warping and change of size when hardening tool steel experienced in the case of some specially exacting work, led me to seek some more reliable and convenient indicator of hardening temperature than those in common use. Dissatisfied with the results obtained by the use in an ordinary workshop of an electrical pyrometer employing a themo junction, with the inconvenience of having to obtain a cooling curve with each sample of steel, and the uncertainty arising from the need of heating the object above the critical point so obtained, to meet the fact that the critical point for heating is higher than that for cooling, I sought to make use of the known fact that at this critical point the magnetic permeability of the steel is changed. With the co-operation of Mr. F. J. Mudford, I experimented with a magnetic induction balance consisting of three similar flat coils of wire placed parallel on a common axis and equally spaced, the inner coil in circuit with a telephone receiver and the outer coil supplied in series with an alternating current, and so connected that at ordinary times no sound was produced in the telephone. When, however, steel was placed between the center coil and either of the outer ones, the magnetic balance was disturbed and a sound produced in the telephone. The steel was then heated, and when it reached the critical temperature and became non-magnetic, the sound in the telephone abruptly ceased, whereupon the steel was quenched and hardened. Steels with carbon contents ranging from 0.7 to 1.35 per cent were hardened in this way at temperatures which, judged by the eye alone, no skilled mechanic would feel safe in using, while the fine grain shown on fracture, together with the invariable hardness, showed how closely the critical temperature had been obtained. In each case on letting the steel cool so that sound was resumed in the telephone the steel failed to harden, although the fall of temperature was imperceptible to the eye. Following this experiment, the magnetic indicator attached to a small muffle furnace was constructed, and has been in daily use in a tool-room for several months, where it has served to indicate temperatures for hardening press tools, milling cutters, taps, reamers, etc., and has established a record during that time in that not a single piece has been lost through warping or cracking in hardening, while the quality of the hardening has been excellent.

The attachment consists of a hardened steel permanent magnet, extended by soft iron pole-pieces into the general form of a horseshoe magnet, the gap of which is in the muffle of the furnace, and is so adjustable that the piece of steel to be hardened may be arranged to fill the magnetic gap. The pole-piece at one side of the furnace is hinged by rocking on the magnet, and is prolonged in such a way as to form a second and alternative magnetic circuit tending to displace the rocking pole-piece and withdraw it from the object being heated. This, however, so long as the object is magnetic, is prevented; but when its temperature rises to the critical point, and the steel object becoming non-magnetic releases the pole-piece, the latter rocks, and in so doing establishes an electrical circuit by which a bell is rung, giving audible warning to the attendant. This device has proved of great practical service by making the work of miscellaneous hardening safe and certain in its results. It is noticeable in every case that the temperature at which hardening is thus safely accomplished is visibly lower than that at which a skilled workman would ordinarily harden steel when endeavoring, on the one hand, to avoid overheating, with the resulting brittleness, cracking, and warping, and on the other hand, the failure to harden, and the certainty that in rehardening these risks of cracking and warping would be multiplied.

The apparatus was shown at the meeting and much appreciated by the engineers present. Samples of steel hardened in the way described were also on view. It was stated by the author that the heating of tools of considerable section needed to be done slowly; otherwise the signal was given too soon, when only the outside layers of steel were at the proper temperature. The president remarked on the useful application of a well-known physical fact for commercial purposes, and thanked the author on behalf of the section.

The increase in the output of basic open-hearth steel has been great in the United States, but it was not until 1899 that the commercial manufacture of rails from that metal was begun. This was done at the Ensley, Alabama, works of the Tennessee Coal, Iron, and Railroad Company, and since then that company has regularly continued the manufacture. The Colorado Fuel and Iron Company, at Pueblo, Col., has begun the manufacture of basic open-hearth rails on a large scale.

* Abstract of paper read before Section G of the British Association.

ELECTRICAL NOTES.

Mention of the "electric" hair brush a few years ago would have been apt to cause the average electrical man to bristle with contempt of what he considered an imposition on the public, says the Western Electrician. But an electric hair brush of a different kind was exhibited at the recent engineering exhibition in London, and this appears to be genuine, at least so far as its use of electric power is concerned. Whether it is meritorious or practicable is a different matter. The device is intended for barbers' use, and is attached by flexible cord to an incandescent lamp socket or other outlet. A small motor, controlled by a switch in the brush handle, is concealed in the body of the brush. The bristles are assembled on a hollow aluminium cylinder, which slides over and forms an inclosing case for the motor. This cylinder is easily detachable, so that changes in the different grades of brush can be readily made to suit the customer, while perfect cleanliness of brushes can be maintained. The "electric" hair brush of former years was supposed to generate a current of electricity in itself sufficient to have a soothing effect on the scalp. It was looked upon with suspicion, to say the least. But the modern article is a machine, perfectly practicable and perhaps useful.

The electric plant of the Nuremberg Exposition was of considerable interest, as here were to be found all the most recent types of steam engines, steam turbines, gas engines, and dynamos. In all there were seventeen different engines having a total of 5,000 horsepower. For lighting the façades of the buildings two three-phase alternators were used. One of them was coupled to a steam turbine, while the second dynamo used a gas engine. The general lighting of the buildings and most of the electric motors were supplied with direct current from thirteen dynamos of different kinds, ranging from 36 to 450 kilowatts. Among these we may mention a turbo-generator group using a Zoelly steam turbine and dynamo of 450 kilowatts, running at 2,000 revolutions per minute, besides two other groups of 340 and 310 kilowatts running at speeds of 110 and 125 revolutions per minute. A three-cylinder Diesel oil motor ran a 330-kilowatt dynamo giving 440 volts. For the use of the circular railway there were two engine-dynamo sets. One of these used a low-carbon gas engine running at 160 revolutions per minute, while the other group had a steam turbine running at 2,500 revolutions per minute. The boilers were placed in an annex building, and the outfit comprised four tubular boilers and one combination boiler, all of which were fitted with superheaters and automatic stoking apparatus operated by electric motors. Four steam pumps for the boiler feed and three pumps driven by electric motors were used here. For the electric fountains there were two turbine-pumps at high pressure, raising the water to 130 feet height. Electric motors of 75 kilowatts were coupled to them, working at speeds of 930 and 1,200 revolutions per minute. Motor-driven pumps, three in number, were also used for the main reservoirs. Each of the ten motor cars of the circular railroad used two motors of 23 kilowatts at 500 volts tension, running at 545 revolutions per minute.

The new single-phase line of the Toledo and Chicago Interurban Railway, recently opened for passenger and freight traffic in northern Indiana and described in the Electric Railway Review, is a typical example of an American "interurban" railway. The present lines as now operated are 40 miles long, and definite plans are laid for a completed system of 100 route miles. The roadbed is built on a fenced private right of way from 50 feet to 100 feet wide for almost the entire distance through the towns of Waterloo and Garrett. The track is laid with 70-pound T-rails. Each rail joint is bonded with one No. 0000 expanded-terminal bond. The cars are operated with 3,300-volt 25-cycle alternating current distributed by a catenary-suspended trolley wire, the trolley being fed at various points by transformer stations taking current from a 33,000-volt transmission line. The average line loss for the distribution system does not exceed 2 per cent. Chestnut poles 35 feet and 40 feet high and set 100 feet apart support the overhead work. The brackets are made of 2-inch pipe, and each has at its outer end an iron pin clamped about the bracket pipe and supporting a Locke porcelain insulator. These insulators carry in their top seats a ⅝-inch special steel messenger cable. The groove trolley wire is supported in a horizontal position by hangers from the messenger cable spaced 50 feet apart on straight track. Clamp ears are used. On curves the trolley wire is held in place by pull-offs, consisting of rods of specially treated wood reaching from the pole to the wire. The 33,000-volt high-tension line consists of two No. 4 hard-drawn copper wires carried on 9-inch triple-petticoat insulators, cemented on 14-inch iron pins at opposite ends of a crossarm. For lightning protection there are arresters in the power house and sub-stations. The generating equipment in the power house consists of two 1,000-horse-power Curtis turbine units generating three-phase 25-cycle current at 3,300 volts. The current from the generators is led to a set of 3,300-volt three-phase 'bus bars. From these one phase is tapped to feed the immediate sections of the trolley wire. Current from another phase is stepped up by three 325-kilowatt transformers to 33,000 volts pressure and distributed to the transformer stations along the line, where it is stepped down to 3,300 volts pressure to feed the trolley wire. For stepping down the line pressure to that of the trolley wire there are at present two transformer stations; a third will soon be erected. The first station is 10 miles from the power house, the second is 10 miles farther on, and the third will be on a branch 10 miles from the second. The high-tension current is stepped down at each station by two 240-kilowatt 33,000 to 3,300-volt oil-cooled transformers. There are two switch panels; one panel controls the oil switches for the line side of the transformers, and the other panel controls two 3,300-volt feeder circuits. The high-tension oil switches are set in separate fireproof compartments. The wiring for the switch and transformer connections is carried on standard line insulators. The circuits on both sides of the transformers may, in emergency, be opened at knife switches which are provided. The transforming station at Garrett has 33,000-volt switches and connections for handling two outgoing feeder lines to the other stations. The rolling stock includes six 52-foot cars built by the Niles Car Company. The seating capacity of the main and smoking compartments is sufficient for fifty passengers. Each car is equipped with four 75-horse-power General Electric alternating-current direct-current motors geared to 40 miles per hour, with platform control. There are also two 45-foot double-end cars with similar motor equipment, for local service, two 52-foot express cars, and one locomotive with the same motors and control. The rolling stock also includes standard flat and box cars.

SCIENCE NOTES.

The trade school in the United States does not hold such an important place as it does in Europe. The cleavage lines in society are so clearly marked that the boy born to a lowly position in life is quite willing to banish ambition, to enter a trade school, and to become a skilled mechanic. With us the boundless ambition of the young American too often entices him to aspire beyond his capabilities and spurn a trade school. Also, the influence from pedagogical circles is so strongly exerted for a "symmetrical development" that trade schools are rated below educational par. However, the demand for them is keen and they are being established because of their economic value. There are six building and mechanical trade schools in New York and Brooklyn, three in Boston, two in San Francisco, and two in Philadelphia. New York has two brewing academies; Chicago and Milwaukee one each. Philadelphia, Lowell, New Bedford, and Atlanta have textile schools. Chicago, St. Louis, Omaha, Peoria, Waltham, Winona, and La Porte have watchmaking and engravers' schools. The universities of Wisconsin and Minnesota and the Iowa College of Agriculture have schools of dairying. For dressmaking, millinery, and the domestic arts and science, schools exist in Boston, New York, Brooklyn, St. Louis, and Philadelphia. Eight cities contain schools to teach barbering. St. Louis has a school for railway telegraphers; Effingham, Ill., has a college of photography, and New York an academy for shipbuilders.

We have but little more definite knowledge of the soil and the principles involved in its treatment than we had sixty years ago. Fertility is not nitrogen, phosphorus, and potassium alone, though the potential value of any field, or State, or country, from the agricultural standpoint, is measured by these constituent elements in its soil, yet it has been demonstrated that soils which contain an abundance of these elements, and which are potentially capable of producing crops for centuries perhaps, are not capable of producing profitable crops without the addition of further amounts of these constituents. The chemical investigator is, therefore, obliged to take into consideration other facts than this. He must, if he would cover the whole field, know something of geology, of botany, of physics, of biology, of bacteriology, and of the other natural sciences, because chemistry alone is not capable of fully compassing the problem, thus the opportunity for specializing in any branch has been very great, and it is because of the broadness of the subject, and the opportunity, as already pointed out, and the necessity, also, for giving immediate help from the knowledge that we have that has prevented in a degree a broad study of the fundamentals essential for enabling genuine progress to be made.

Considerable interest, says Knowledge and Scientific News, is being shown in the light thrown upon the origin of limestone in the researches conducted by Messrs. Frederick Chapman and Douglas Mawson, in regard to the importance of *Halimeda* as a reef-forming organism. The fresh-water *Chara*, calcareous algæ, nullipores, and purple sea-weeds of the type of *Lithothamnion* have long been known to form the basis of limestones and coral reefs, but in *Halimeda* we have a calcareous green alga performing a similar operation. The material obtained in the great boring, the lagoon borings, and lagoon dredgings at Funafuti has yielded a considerable quantity of *Halimeda;* and Dr. Guppy has described a *Halimeda* limestone in the Solomon Islands. Evidence such as this shows that the important deposits of calcareous plant remains forming at the present day can scarcely be paralleled by any deposit formed in past geological times, except, possibly, the limestones of the Alpine Trias, which owe their origin to the thallophytes *Diplopora* and *Gyroporella*. Among other *Halimeda* limestones may be mentioned those of Christmas Island, Fiji, and Tonga, and the New Hebrides, but these differ considerably one from the other in the condition of preservation of their chief organic contents. *Halimeda* seems to be more liable to decay than *Lithothamnion*, corals, or foraminifera, and yet it appears to retain its structure to a considerable depth in reefs. Much of the fine powdery limestone associated with coral reefs, and more especially with upraised coral islands, may be primarily

due to lagoon and other deposits formed by the agency of *Halimeda*.

ENGINEERING NOTES.

Who can help admitting that the employment of gas power has actually become a factor of consequence in the world's total energy output when it is considered that in Germany, a small country of four-fifths the size of Texas, there are to-day in the iron and coal industry alone, in active service or in contemplation, 136 gas blowing engines with 161,300 horse-power, 200 gas dynamos with 206,300 horse-power, 11 gas engine roll drives with 17,000 horse-power, and 47 coke-oven dynamos with 40,000 horse-power, besides four engines with 1,500 horse-power, for other purposes, or a total of about 400 large gas engines with a combined capacity of 420,000 horse-power?

For the better protection of its extensive warehouses and docks at Huelva, in Spain, the Rio Tinto Copper Company has recently acquired a powerful and interesting gasoline motor firefloat, in which the vessel itself and the pumps for throwing the water jets are driven by this type of motor. The float measures 45 feet in length by 10 feet beam, and has a draft of 3 feet aft. The hull is constructed of steel throughout. The engine compartment is placed amidships, the engineers' cabin is forward, while the space aft is reserved for the stowage of hose, etc. The gasoline motor is of the vertical type with six cylinders, developing 60 horse-power, and drives a single screw propeller through a clutch and shaft. In the official test the float attained a speed of 9 miles per hour. The pumps for discharging the jets are driven by the gasoline engine through clutches, and their combined capacity is 1,200 gallons per minute. Each pump supplies three hose connections on deck, capable of throwing 1½-inch, 1¾-inch, and 2-inch jets respectively, or the entire delivery can be directed into one swiveling monitor throwing one large stream. The water supply is obtained through suction strainers submerged in the water on either side of the float.

The advantages of steam omnibuses for public service work may be generally summarized as follows: The employment of a safe and cheap fuel; freedom from noise and vibration; absence of smell; smooth and silent action of the machinery; quick acceleration without jerkiness; flexibility of drive and simplicity of control; large reserve power for hills and for overcoming the inertia of starting; entire absence of change-speed gears; entire absence of electric ignition; entire absence of friction clutch. To realize these important advantages, a very perfect steam generator is necessary. It is here that the principal engineering difficulty has been encountered. The usual methods for the generation of steam are characterized by smoke, dirt, sparks, ashes, almost constant attention to the water-feed and to stoking, trouble from priming, from incrustation, and from leakage. Therefore it is safe to conclude that the usual methods of steam generation are unsuited for the purpose. To produce a generator free from the above vices, and which is regular and reliable in action, has proved a most serious problem. It is surprising to many engineers to find that steam can be generated automatically as required without any of the preceding drawbacks, and that the generator, instead of being a delicate thing needing careful handling and attention, has been made robust and healthy and for all practical purposes, "fool-proof."

In gas-making operations on a large scale the important thing is the recovery of by-products. The ammonia recovered in the manufacture of Mond gas is a great argument in favor of that form of gas, but large producers are required to secure the full advantage of this process. With a gas producer the ratio of the heating value of the gas to that of the fuel from which the gas is made is called the thermal efficiency of the producer; of course the fuel burned under the boiler for steam-raising purposes must be added to the coal used in the gas generator. When gas is used for driving a gas engine it is cooled after it is made, and obviously the thermal efficiency of the producer is the ratio of the heat in the cold gas to the heat of the fuel from which it is made. There are many forms of calorimeter made for the purpose of finding the heat value of the cold gas. It may be interesting to record a few thermal efficiencies. The manufacture of coal gas with bituminous and cannel coal gives 22 per cent. Water gas (using coke) gives an efficiency of 71 per cent. Dowson gas is obtained from anthracite with an efficiency of 73 per cent. Mond gas seems to vary, for the efficiency is given as from 84 to 67 per cent. With blast-furnace gas the efficiency is roughly 50 per cent. We must also consider the thermal efficiency of the gas engine. The owner of combined plants naturally wishes to know how many cubic feet of gas is used for every brake horse-power per hour. The ratios of the number of cubic feet of coal gas, Dowson gas, and Mond gas consumed per indicated horse-power per hour are in the proportions of 374, 1,636, and 1,690, worked out on a theoretical basis, and assuming that there are no losses by radiation, etc. The thermal efficiency of the engine is the best equivalent of the work done on the piston as shown by the indicator diagram, divided by the total calorific value of the fuel used. Indicator diagrams on internal-combustion engines are often difficult to take with any great accuracy, especially with the high speeds now used for smaller gas engines. So that we usually seek the over-all efficiency of the engine, which is obtained by computing the number of thermal units required per hour per brake horse-power.

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